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GASTRIC MUCOSAL RELIEF

A MODIFIED SEDIMENTATION METHOD, USING A COLLOIDALLY SUSPENDED BARIUM SULPHATE[1]: A PRELIMINARY REPORT

By ROBERT A. ARENS, M.D., *and* SIDNEY D. MESIROW, M.D., Roentgenologist and Assistant Roentgenologist, Michael Reese Hospital, *Chicago*

RECENTLY, in this country, there has been a revival of interest in the demonstration of mucosal patterns in the stomach and duodenum, as an aid in establishing the normal and abnormal in gastric and duodenal diagnosis.

This paper will attempt to demonstrate the possibility of a modification of the sedimentation method, by no means a new idea, but one which represents a slight departure from those used in the past.

HISTORICAL NOTE

As early as 1897, Roux and Balthgard, apparently independently and contemporaneously with Walter Cannon in this country, first used a bismuth opaque meal in demonstrating the motor phenomena of the stomach.

Holzknecht and his group, in 1898, probably saw fluoroscopically the flow of bismuth opaque meals over the gastric rugæ. In 1906, they used a watery suspension of bismuth subnitrate in the preliminary part of the fluoroscopic study of the stomach (10 grams bismuth subnitrate in 50 grams of water, to which was added a tablespoonful of milk sugar). Palpation of the stomach in the erect posture made possible the visualization of the mucosal folds. After this procedure and while the stomach still contained the bismuth suspension, they distended the stomach by having the patient ingest an effervescent mixture of from four to five grams tartaric acid and from five to seven grams of sodium bicarbonate. This they followed by the usual opaque meal, four hundred grams of milk gruel with thirty-five grams of bismuth subnitrate.

This examination is detailed because of its resemblance to our own procedure.

With the advent of the Snook x-ray transformer, in 1907, and the distinct improvement in visualization due to "stopping" gastric peristalsis, further impetus was given to gastro-intestinal examinations by these methods.

Cole, in 1909, demonstrated gastric rugæ by using the principle of sedimentation of bismuth subnitrate from a *watery suspension* as a special technic. His first films compare very favorably with the more modern methods of examination.

Akerlund, in 1921, working with Forssell, whose classic monograph in 1913 laid the fundamentals of the anatomy and physiology of the stomach before the profession, applied the method of the "thin layer" to diagnosis of the duodenal bulb

[1] "Rugar:" furnished through the courtesy of McKesson & Robbins Company.

lesions by exerting external pressure to displace all but a thin layer of opaque medium from the bulb.

Since then, innumerable observers have contributed both to the relief and thin layer methods, the majority, however, having tended to avoid the principle of sedimentation to demonstrate the rugal pattern.

Pribram and Kleiber (1927), Hilpert (1928), and Vallebona (1926) revived the use of barium suspension and air distention. Small amounts of barium suspension were ingested and distributed by manual pressure, then the stomach was distended by air injected through a small tube (Pribram, Kleiber, and Hilpert), or by chemical means (Vallebona).

The Cole Collaborators, 1934, whose procedure we largely followed, reviewing previous methods, discussed the distribution of an opaque salt by sedimentation, modifying their original procedure of giving the patient one gram of bismuth subcarbonate in four ounces of water, by giving a larger quantity (eight ounces) of water, so that the opaque salt would settle out on a smoother surface and when, after fifteen or twenty minutes, the water was withdrawn, the stomach, diminishing in volume, caused the mucosal folds to appear. This method, they decided, however, could be applied only in special cases as an adjunctive method rather than a routine procedure.

ELABORATION OF METHOD OF MUCOSAL RELIEF

It is important to establish here the fundamental necessity of combining both the fluoroscopic and roentgenographic findings in arriving at a satisfactory diagnosis.

Therefore, in planning the drink to be used, it was essential that it be made sufficiently opaque to enable proper fluoroscopic observation, yet not interfere with radiographic demonstration of the mucosal folds. This, it was felt, could not be accomplished by the administration of a single opaque meal, since it was known that a meal sufficiently opaque to be visualized fluoroscopically was not sufficiently thin to allow the suspended barium to settle out on the mucosal folds satisfactorily.

At first, using a dilution of barium and skimmed milk in proportion of one-to-four, we found that the barium stayed in the stomach too long. With further dilution, up to one-to-thirty, the same objection arose, along with the fact that the barium "caked" rather than separated out in a thin layer over the mucosa.

In the attempt to correct these faults, and because it was felt that the skimmed milk contained sufficient fatty material to delay gastric motility, and also had the property of keeping the barium in suspension too long, we turned to diluting with water. This, we found, was immediately but only partially successful, the dilution of apparent maximum efficiency lying between one-to-ten and one-to-fifteen.

Since we still had trouble because the barium settled out in clumps, rather than in a finely divided precipitate, we were prevailed upon to experiment with "Rugar," a colloidally suspended barium sulphate which is freely miscible with milk or water.

This, we found on dilution with *water, not milk*, to one-to-fifteen strength, was ideal for the purpose intended. The meal, about sixteen ounces, was given to the patient, and after he had lain alternately on his right and left side for only fifteen minutes, films could be taken, the greater proportion of which were successful in demonstrating the gastric pattern, since during that time the barium had settled out and most of the fluid had been evacuated from the stomach. It was then felt that we could further improve the visualization by the introduction of gas or air into the stomach, in direct similarity to double contrast in pneumocolon.

Use of the Rehfuss and Levin tubes, followed by air inflation, was not satisfactory. Because of the discomfort to the patient, and because in out-patients the method entailed too much difficulty, we turned to gas distention by allowing the

patient to ingest Seidlitz powders, drinking each powder separately to insure maximum gas formation. The action of the tartaric acid and sodium bicarbonate in production of carbon dioxide gas is well known, and had been used as early as 1906 by Holzknecht and his school, if not earlier.

The results were eminently successful, with the following relatively unimportant exception. It was found that with too much distention, most of the rugal folds were "ironed" out, a finding which we expected, from the experience of the Cole Collaborators. "Distention of the stomach and duodenum has the disadvantage of diminishing the prominence of the mucosal relief."

In connection with Akerlund's thin layer method for the duodenal bulb, we felt that attempts at gastric compression would fail, since in the average patient it was frequently impossible to palpate the fundus because it lay so high behind the costal arch.

Because it was felt that it was essential to observe the stomach fluoroscopically, the patient was given a regular meal and the stomach manipulated and palpated, following which films were again taken, in order to check completely the findings of the first method.

SOURCE AND AMOUNT OF MATERIAL

A series of gastro-intestinal patients, numbering 30 unselected cases, were then examined, employing the method. By far the greater number were normals, insofar as the stomach was concerned, allowing the development of familiarity with the average normal pattern. There were, however, several which both demonstrated the efficacy of the method and suggested the possibilities of its application.

Of the abnormal, one proved to be an enormous polypous adenocarcinoma of the cardia of the stomach, very well demonstrated by the "combined method" ("Rugar"/water $^1/_{15}$ with Seidlitz powder) —see Case 6.

Another revealed the presence of one gastric ulcer, beside the one discovered in the duodenum, whereas the usual meal had revealed only the duodenal lesion.

Still two others graphically outlined enormous gastric ulcers with the surrounding edema and disturbance in the rugæ about the crater.

TECHNIC

The patient was brought to the department without breakfast, stomach empty. The meal (sixteen ounces containing "Rugar," the colloidally suspended barium, and water in proportion of one-to-fifteen) was given the patient while under fluoroscopic control (in some cases the meal was of sufficient density to permit visualization).

The patient was then placed in the prone position and told to lie first on the left side, then on the abdomen, and then on the right side, dividing the fifteen minutes equally. The patient then took each of a pair of Seidlitz powders and was asked not to belch. Films of the stomach were then immediately taken, in the right lateral, right oblique, and anterior positions. The patient was then given the routine barium meal to enable visualization roentgenoscopically and allow roentgenographic check-up. Films were then taken again.

The following are case reports of the typically normal cases and those which were unusual from the standpoint of pathology.

NORMAL CASES

Case 1. K. J., white female, 32 years of age; complained of epigastric pain, headache, and vomiting for six months. Physical, laboratory and roentgen examinations were negative for abnormalities. (See Figs. 1-*A* and 1-*B*.)

Comment: Instead of the usual vertical rugal markings, it is noted here that the markings are scalloped and irregular, suggesting larger rugal folds irregularly distributed on the greater curvature. This examination was done without gas distention. It is highly likely that, while the roentgen examination was deemed negative, the demonstration of these heavy

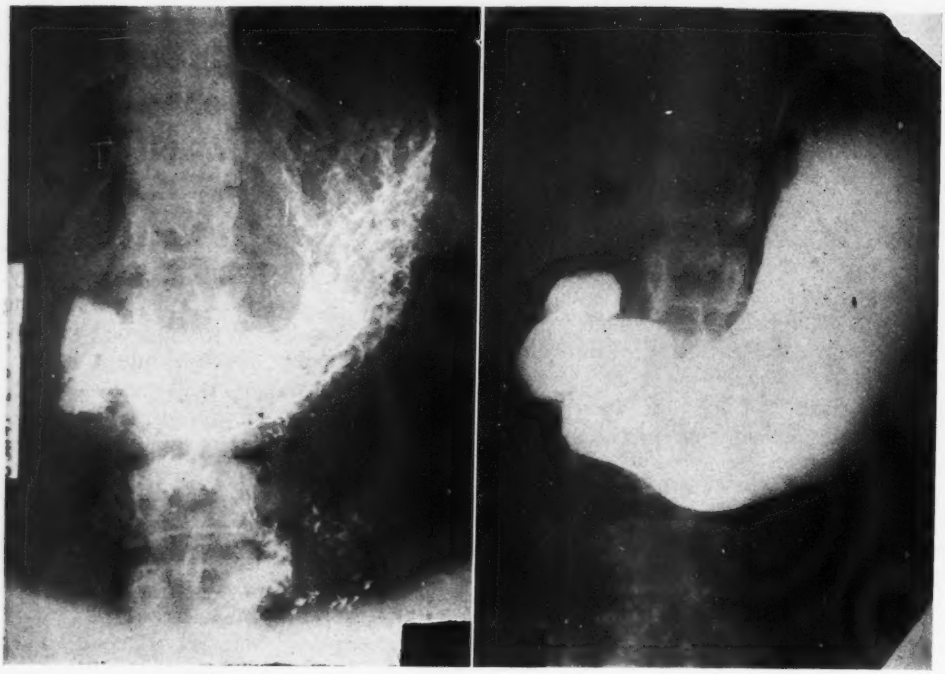


Fig. 1-*A*. Fig. 1-*B*.

Figs. 1-*A* and 1-*B*. Case 1. Scalloped markings in cardia and fundus suggest rugal hypertrophy.

Fig. 2. Case 2. Antrum and distal fundus certainly negative.

rugæ may be significant of a hypertrophic gastritis.

Case 2. S. J., colored female, 50 years of age, complained of a weight loss of 20 pounds in four years, epigastric pain and somnolence for two or three weeks, and nocturia for two months.

Physical examination revealed hypertension (208/94), tenderness in the epigastric gall-bladder area, with a questionable mass which was thought to be gall bladder.

Roentgen examination was negative except for a pathologic appendix (Fig. 2).

Comment: With less evacuation of sedimentation meal, the gross vertical rugal folds are shown. Here one can be absolutely sure that there is no lesion in the antrum or distal fundus.

Case 3. White female, 23 years of age, had complained of epigastric pain for two months. She had been a known diabetic

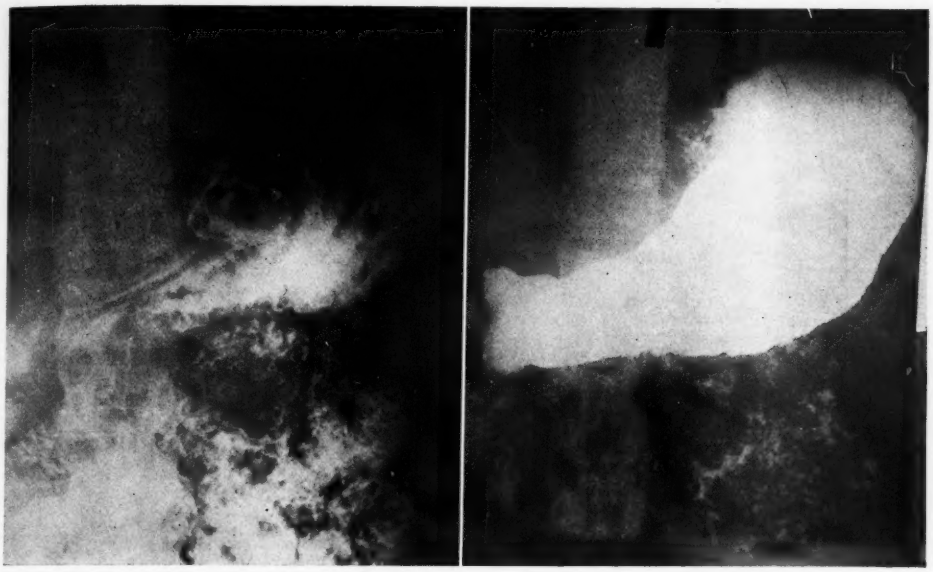


Fig. 3-*A*. Fig. 3-*B*.
Figs. 3-*A* and 3-*B*. Case 3. Gross rugal markings are well shown.

for seven years and the diabetes was controlled by insulin.

Physical and laboratory examinations were negative except for blood sugar of 325 mgm. per c.c. Roentgen examination was negative. (Figs. 3-*A* and 3-*B*.)

Comment: Similar to Case 2; vertical rugæ of cardia and fundus well shown.

Case 4. N. W., female child, 12 years of age, complained of epigastric pain of two months' duration.

Physical findings were negative for abnormalities. Laboratory findings were within normal range.

Roentgen findings: Questionable duodenal defect. (Figs. 4-*A*, 4-*B*, 4-*C*, and 4-*D*.)

Comment: The films were taken in the anterior and right oblique positions in both methods. The cardia and fundus are extremely well shown. Barium sedimentation is even and uniform throughout—definite assurance that this portion of the stomach is negative.

PATHOLOGIC CASES

Case 5. H. L., white male, 73 years of age, complained of marked anorexia, weight loss of 15 pounds in one year, precordial pain, and loss of appetite due to epigastric fullness.

Physical findings revealed only a senile loss of tissue turgor, pulmonary emphysema, and cardiac enlargement.

Laboratory examination was negative except for a lack of free acid in the gastric analysis. There was no blood in the gastric contents.

Roentgen examination revealed an enormous polypous gastric malignancy in the cardia, revealing several polypous filling defects and extending down the lesser curvature and posterior wall to the incisura angularis.

Comment: The "double contrast" method beautifully demonstrates the extent and nature of the lesion, two large polypous extensions of the lesions on the posterior wall and lesser curvature, and a

smaller polypous extension from the outer superior quadrant of the cardia. (See Figs. 5-*A* and 5-*B*.)

Fig. 4-*A*. Fig. 4-*B*.

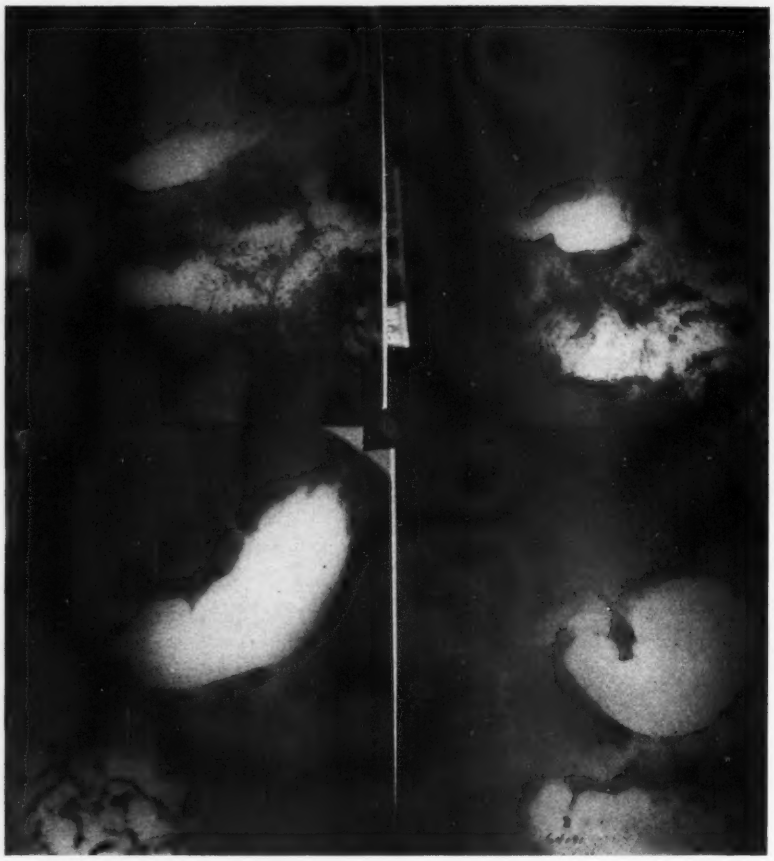


Fig. 4-*C*. Fig. 4-*D*.

Figs. 4-*A*, 4-*B*, 4-*C*, 4-*D*. Case 4. The fundus and cardia are well shown and unquestionably negative for abnormalities.

Case 6. A. B., white male, 60 years of age, complained of intermittent sharp epigastric pains with vomiting two hours after meals for the past two years. He ate five or six small meals per day to avoid pain.

Physical examination was negative for abnormalities.

Laboratory findings: Blood count revealed an elevated white blood count (13,000–21,600); gastric analysis showed a free acid of 40 per cent, a total acid of 75 per cent. No blood in vomitus, gastric analysis, or stool.

Roentgen examination revealed a large penetrating ulcer crater on the lesser curvature in its middle third. Gastric retention 30 per cent at twenty-four hours. (See Figs. 6-*A* and 6-*B*.)

Surgery: A tremendous ulcer crater was shown on the lesser curvature of the stomach, penetrating into the pancreas, the defect in the stomach about the size of a silver dollar.

Fig. 5-*A*. Fig. 5-*B*.

Figs. 5-*A* and 5-*B*. Case 5. Note the clearness with which the combined method shows the intragastric neoplastic protrusion.

Pathology: Chronic penetrating benign ulcer crater, five centimeters in diameter. There was no evidence of malignancy.

Patient subsequently developed parotitis and peritonitis and died.

Comment: The routine method reveals a large penetrating crater on the lesser curvature.

Sedimentation meal reveals the crater with lack of rugal markings in crater proper, but since the retained fluid continually washed the markings away, the findings are not as typical as could have been desired.

Case 7. A. F., white female, 54 years of age, complained of a weight loss of 20 pounds in one year, epigastric and lower abdominal pain soon after eating, and vomiting. She gave a previous history of removal of a pseudomucinous papilliferous cystadenoma of the ovary.

Physical examination revealed a large, tender, nodular liver, a nodular mass in the epigastrium not related to the liver, and also one in the right lower quadrant.

Laboratory findings: Ewald meal with histamine revealed no free acid, but blood. Because of the former ovarian pathology, the question of a Krukenberg tumor was raised. A review of the microscopic sections failed to reveal any evidence of malignancy.

Roentgen examination revealed a filling defect at the distal end of the stomach fundus, extending into the antral area on the greater curvature side. The walls of the antrum were rigid. Because of the rigidity, the *filling defect*, and the *lack of normal rugæ* in this area, it was felt to be a primary gastric malignancy. (See Figs. 7-*A* and 7-*B*.)

Surgical exploration revealed a large scirrhous carcinoma involving the junction

Fig. 6-*A*. Fig. 6-*B*.

Figs. 6-*A* and 6-*B*. Case 6. Because of retention, the mucosal pattern was not constant, but the crater is revealed by both the routine and the sedimentation methods.

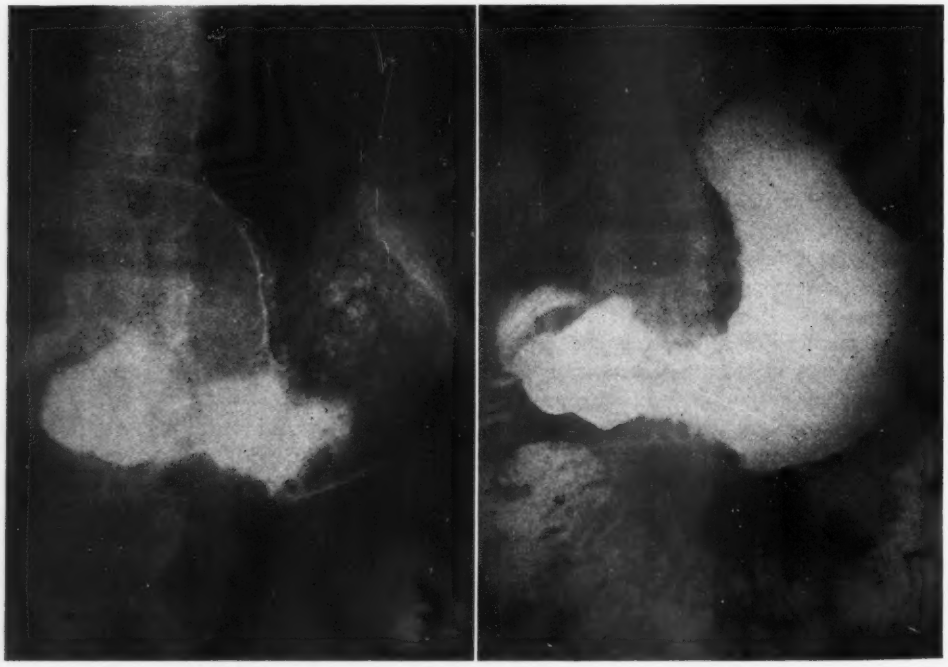


Fig. 7-*A*. Fig. 7-*B*.

Figs. 7-*A* and 7-*B*. Case 7. Note filling defect in distal fundus with loss of rugal pattern which is better shown in Fig. 7-*A* and which proves conclusively that the tumor is intragastric.

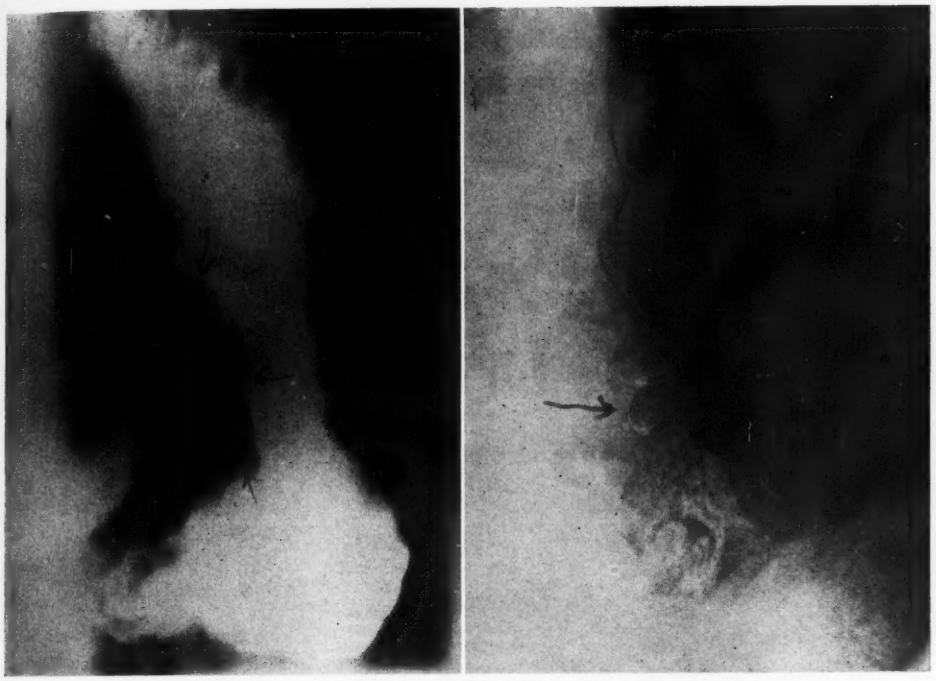


Fig. 8-*A*. Fig. 8-*B*.

Figs. 8-*A* and 8-*B*. Case 8. The fluoroscopic film Figure 8-*A* reveals the crater with surrounding edema. The sedimentation film reveals in addition to the above, a collection of barium within a crater which was overlooked and which represented a second ulcer, found at surgery. (Arrow to the right in Figure 8-*B*.)

of the fundus and pyloric antrum, with large liver and omental metastases.

Comment: Both routine and sedimentation methods revealed the filling defect at the distal end of the fundus, extending into the antrum. Because of the pressure of the spine and the relatively small amount of intragastric material, the filling defect is more accentuated in the latter method. Also, the absence of normal rugæ in this area is better shown in the sedimentation film. It was felt, in this case, that the sedimentation method distinctly proved that the lesion was primarily intragastric.

Case 8. A. R., white male, 65 years of age, complained of dull aching epigastric pain, with vomiting, one hour after meals, of five months' duration. Physical examination was negative, except for mid-abdominal tenderness.

Laboratory tests revealed a faint trace of blood in the vomitus, and a gastric free acidity of 12.5 per cent. No blood was noted in the stool.

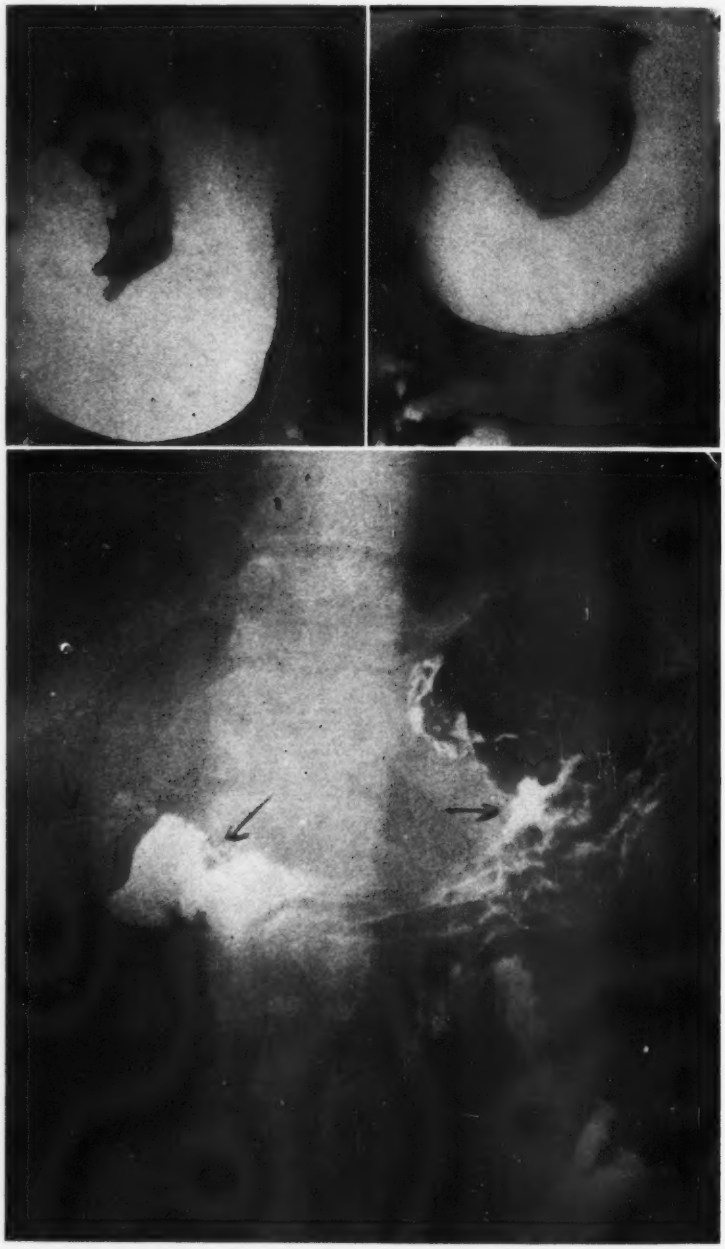
Electrocardiogram: "Myocardial damage."

Roentgen examination revealed a plateau-like intragastric filling defect projecting into the lumen on the lesser curvature, extending above and below the incisura angularis, in the summit of which there was a large crater (Fig. 8-*A*).

Surgery revealed the presence of one large benign ulcer on the lesser curvature, with marked surrounding edema, and also another small crater about six centimeters from the above, on the posterior wall, which roentgen examination failed to reveal.

Comment: The sedimentation method revealed the first lesion quite clearly,

showing the crater and surrounding edema. Just to the left, on the posterior wall, between both curvatures, one notices a faint collection of barium to which no attention was paid, but which undoubtedly represented the second lesion (Fig. 8-*B*).



Figs. 9-*A*, 9-*B*, and 9-*C*. Case 9. Routine meal reveals only duodenal ulcer and cholelithiasis whereas the sedimentation film (Fig. 9-*C*) shows the gastric lesion beside the above.

Using the routine method made the demonstration of either lesion difficult and

it was only under fluoroscopic localization that we were able to demonstrate the larger lesion radiographically.

Case 9. E. P., white female, 63 years old, complained of gnawing epigastric pain for six weeks and a weight loss of 35 pounds in five or six years. Physical examination revealed diffuse abdominal tenderness, more marked in the right lower quadrant.

Laboratory findings: Gross tarry blood in the stools on seven occasions.

Roentgen examination revealed both gastric and duodenal ulcers and cholelithiasis. (See Figs. 9-*A*, 9-*B*, and 9-*C*.) No surgery was done.

Comment: The sedimentation method here showed especially well the gastric crater filled with barium and the disturbance in rugal pattern about it, while the routine examination was doubtful as to the presence of a definite ulcer.

DISCUSSION

We are in complete agreement with the Cole Collaborators that the sedimentation method cannot be used as a routine method to the exclusion of the regular barium meal, and hence must be used as an adjunctive examination in special cases, for the reason that the resultant films are not as constant in depicting gastric abnormalities as is the standardized meal.

However, since it is difficult to place the patient in such a position as to demonstrate the filling defect or crater in profile, so that the defect or crater can actually be seen, and since the routine meal is sufficiently opaque to obscure visualization in any but the profile position, it is felt that the sedimentation method could, in a case presenting puzzling features, considerably add to our present armamentarium.

For lesions to be demonstrated in the cardia, the sedimentation method with partial gas distention is excellent, outlining tumor masses or abnormalities in the same manner that the pneumocolon reveals lesions in the colon.

SUMMARY

A modified sedimentation is described using "Rugar," a colloidally suspended barium, freely miscible with water and milk.

A series of 30 gastric examinations is presented, with case reports of the typically normal and several of the unusual abnormal cases.

It is hoped that the method outlined will form a basis for further study of the sedimentation method as a means of demonstration of the mucosal relief of the stomach.

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THE BIOLOGIC MEASUREMENT OF DEPTH DOSES

By CHARLES PACKARD, PH.D., *New York City*

From Columbia University, Institute of Cancer Research, F. C. WOOD, M.D., Director

THE purpose of this article is to show how depth doses can be measured by means of a biologic method, and to indicate the degree of precision which may be obtained. This is illustrated by results of tests on *Drosophila* eggs.

The use of living test objects, such as eggs or seeds, as indicators of dosage is by no means new. As early as 1915, Ritter, Rost, and Kruger (19) employed large numbers of beet seedlings in order to compare the relative biologic effectiveness of different Sabouraud doses. Krönig and Friedrich (10) used frog eggs in their experiments to test the action of different x-ray wave lengths. Later, Jüngling (9) used peas and beans to determine depth doses. The seedlings were irradiated in a wax chamber held at various levels below the surface of the phantom. The criterion of effect was the relative increase in root length after exposure. These investigators and others who made similar experiments, realized that their results were not wholly satisfactory, but they were convinced of the value of the method. Lorenz and Rajewsky (11) remarked that "since the ultimate aim of measurement is to determine the biologic effect of the rays, a biologic method would appear to be the most logical." They concluded, however, on the basis of experiments already made, that the results were of no great value since they showed only the order of magnitude of the doses which were to be measured.

The unsatisfactory results were due largely to inadequate methods. It is now realized that seeds used in this kind of experiment must be carefully selected for size, and must be in approximately the same stage of germination. After exposure great care must be exercised to prevent injuries to the growing root tip, and to maintain a proper degree of moisture and temperature. With all these precautions, the amount of root growth is still variable. Thus, Henshaw and Francis (6) find in their control material consisting of 17 samples, each containing 25 seeds, that the average root length of the different samples varies to a considerable extent; however, because of the large number of individuals which they used, the amount of variation, from a statistical point of view, is not large. It is evident that if the relative magnitude of surface and depth doses is estimated by the amount of root growth, or by some other biologic reaction, the comparison is between two quantities both of which may be affected by the normal variability of the test objects. Only by using large numbers of specimens can this source of error be eliminated.

In the past few years appropriate biologic methods and accurate physical measurements have produced significant data regarding depth doses. Hussey (8), using *Drosophila* larvæ as indicators, found that depth doses in a paraffin phantom are much the same as those obtained with thimble chamber dosimeters. Sugiura (20) irradiated particles of Mouse Sarcoma 180 at various depths in a phantom, and estimated the dose which they received, as compared with the surface dose, by finding the proportion of takes after the particles had been inoculated into healthy animals. The percentage depth doses obtained in this way were not unlike those determined by physical means. Henshaw and Francis (6) have used wheat and lettuce seedlings, determining the surface and depth doses in a paraffin phantom for both 200 kv. x-rays and for gamma rays. They observed that for x-rays the depth doses measured by the seedlings were somewhat lower than those indicated by ionization readings.

As test objects for studying depth dosage, the eggs of *Drosophila* possess an advantage over other kinds of material in that their quantitative reaction to equal doses of radiation remains the same year after year; and the amount of variation between the results of repeated tests is relatively small. To illustrate the constancy in response, and the amount of variation which may be expected in these experiments, the data in Table I are presented. These form a part of a large series of similar tests made during the past six years. The eggs were exposed in air, free from scatter, to doses measured with a calibrated Victoreen dosimeter. In all cases, the voltage was 120 kv., and the filtration, 0.25 mm. Cu and 1.0 mm. Al. The half value of the beam was 0.33 mm. Cu. It will be seen that the differences between the results of individual tests and the average of the series to which they belong are not large, the greatest being 6.8 per cent and the smallest, 0.2 per cent. The magnitudes of the Probable Error of the Means indicate that these averages do not differ significantly from a theoretically correct average which might be obtained from a very large number of similar tests. Statistical analysis of the entire series of tests, now numbering more than 200, show that the Probable Error of a single observation is ± 2.4.

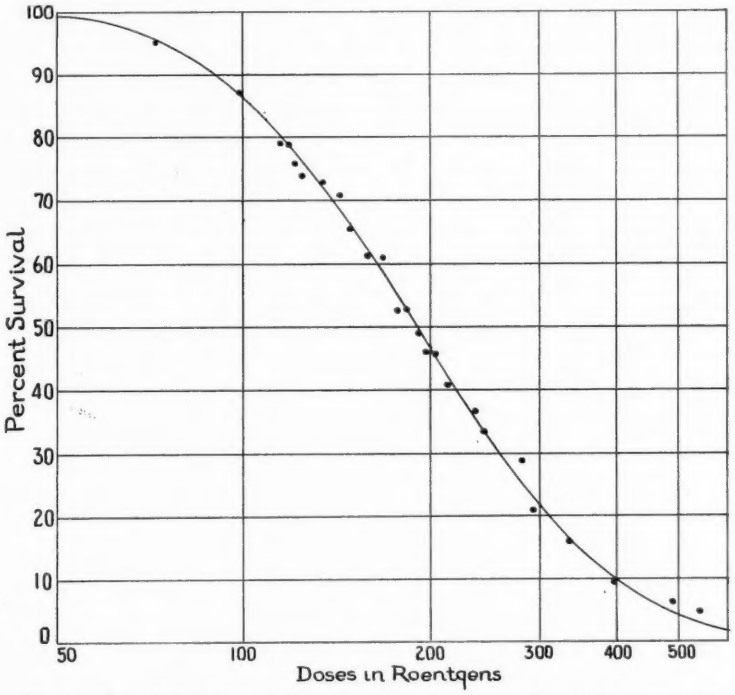

Fig. 1. The relation between the percentage of surviving *Drosophila* eggs and the incident dose. The logarithms of the doses are given on the abscissa.

The relation between dose and biologic effect, that is, the percentage of surviving eggs in a sample, is best shown by plotting all the data obtained in the manner just described, against the logarithms of the doses. The resulting curve (Fig. 1.) is a symmetrical ogive. The fact that the amount of effect of injurious agents often increases with the logarithm of the dose rather than directly, was remarked as long ago as 1879 by Galton, and has been

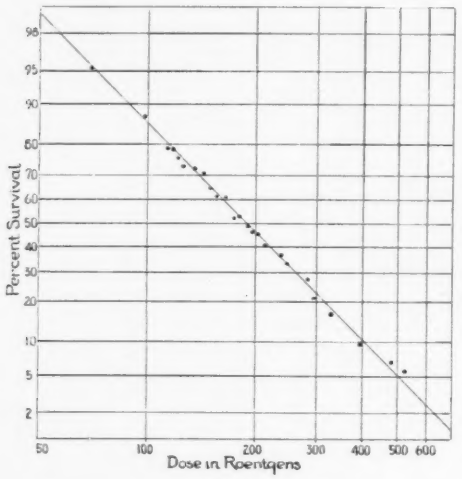

Fig. 2.

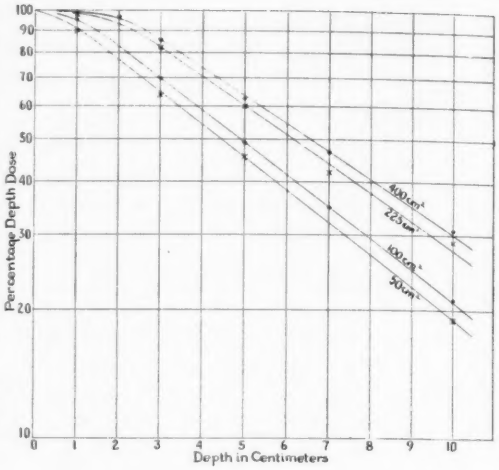

Fig. 3.

Fig. 2. The data appearing in Figure 1 are plotted here on logarithmic probability paper.
Fig. 3. Percentage depth doses under portals of different areas. The conditions of exposure are: 120 kv.; 0.25 mm. Cu and 1.0 mm. Al filter; 30 cm. distance; half value layer, 0.33 mm. Cu.

observed more recently in many toxicological studies. The curve is the integrated form of the familiar probability curve and can be changed into a straight line, for statistical purposes, by plotting it on logarithmic probability paper (Fig. 2), or by transforming the data, instead of the paper, into probability units, following the methods devised by Bliss (1), and plotting them on co-ordinate paper. The curve now shows how many roentgens must be delivered in order to produce any desired percentage of survivors. The relation between dose and biologic effect is not altered by changes in the wave length of the incident beam. Tests made with voltages ranging from 12 to 550 kv. show that when the doses are measured by means of open ionization chambers, equal numbers of roentgens produce equal amounts of reaction. The curve can be used, therefore, without correction for experiments on *Drosophila* eggs when ordinary voltages are employed.

Definite doses result in definite percentages of survivors. The reverse statement is also true; the percentage of survivors is an accurate measure of the dose. This biologic method of measurement, briefly described elsewhere (12, 13), is illustrated in Table I where, on the lowest line, appear the number of roentgens which, as shown by the curve, correspond to the average percentage of survival in each series of tests. The agreement between these figures and the actual doses,

TABLE I

Dose	118 r	149 r	202 r	246 r
Percentage of survival	73.9	58.5	41.2	28.8
	75.8	60.3	42.0	28.9
	76.2	63.0	42.1	29.2
	76.9	63.5	42.2	30.9
	78.0	63.6	44.3	31.6
	78.3	65.0	45.0	32.0
	78.2	65.1	45.1	32.2
	79.2	66.0	45.8	33.8
	79.5	66.1	45.9	36.5
	79.8	67.0	46.3	37.2
	80.1	67.2	46.6	38.2
	81.2	67.3	47.0	38.6
	82.4	68.0	47.4	39.2
	85.5	69.1	48.4	
		69.3	48.8	
			49.7	
Ave.	78.9	65.3	45.5	33.6
P.E.$_m$	±0.52	±0.52	±0.41	±0.64
Biol. r	120	151	203	244

To show the degree of variation in results when the same dose is given to different samples of eggs; and the number of biologic roentgens corresponding to the average percentage of survival.

shown at the top of the table is very close indeed. In these series, the number of separate tests is larger than is needed to obtain a fair average. Not more than ten are necessary when all the experimental conditions are satisfactory.

Because the doses thus measured are estimated by means of this biologic standard and only indirectly from physical measurements, they should be clearly distinguished from the latter. This unit of measurement is called, therefore, the Biological Roentgen (14). Although strictly speaking, the use of such a term is not correct, yet the expression conveys a real meaning and therefore is permissible. Table II illustrates the way in which doses

TABLE II.—120 KV.; 0.25 MM. CU PLUS 1 MM. Al; 30 CM. DISTANCE; AREA OF PORTAL, 400 SQ. CM., DEPTH, 3 CM. BELOW THE SURFACE OF THE PHANTOM

Dose	% Surv.	Biol. r	Ratio
103 r	76.4	125	121.4
103	74.8	129	125.2
119	67.4	147	123.5
120	68.8	143	119.3
122	65.2	152	124.6
129	62.1	160	124.0
141	59.9	165	117.0
144	58.2	169	117.4
147	59.4	166	112.9
147	57.6	171	116.3
149	54.7	178	119.4
152	50.0	190	125.0
172	44.0	207	123.5
176	44.6	205	116.5
183	37.5	229	125.1
185	38.4	226	122.2
218	28.9	263	120.6
Ave.			120.6
P.E.$_m$			±0.57

To illustrate the method of determining depth doses by the biologic method.

are determined in biologic roentgens. In this series, the eggs were submerged to a depth of 3 cm. in a water phantom. The incident doses, measured without scatter, result in percentage survivals shown in the second column. In the third column are the doses expressed in biologic roentgens; that is, the number of roentgens shown by the curve to correspond to each percentage of survival. The ratios between these and the incident doses appear in the fourth column. The average of these ratios is 120.6 per cent. Thus, at 3 cm. depth under the conditions stated in the caption, the intensity of radiation is about 21 per cent greater than that of the incident beam. The amount of variation between the separate tests is, in this instance, small. Other depth dose data given below, indicate that in general it is larger than when the tests are made in air, without scatter. This is undoubtedly due to the difficulty of maintaining exactly similar experimental conditions throughout the entire series of depth dose exposures.

EXPERIMENTAL

The arrangement of the apparatus used in these experiments is as follows: The x-ray tube is enclosed in a lead-lined box which effectively stops all stray radiation. A lead glass bowl, having an aperture of 10 cm. at the base, surrounds the tube. Below this, 22 cm. from the target, is a lead diaphragm with a portal of 15 × 15 cm. which is closed by the filter. A sliding lead door below the portal serves to interrupt the beam. The water phantom, 38 × 38 × 30 cm., made of wood, is covered by a lead sheet having a portal of the desired size. This sheet is 1 cm. above the surface of the water, which, in all of the experiments, was 30 cm. from the target. With this arrangement of diaphragms most of the off-focus radiation, which according to Thoraeus (21), may add as much as 25 per cent to the intensity of the direct beam, reaches the surface of the water. The surface dose is thus at a maximum, but a considerable part of the off-focus radiation enters the water at such an angle that it passes to the sides of the phantom and has very little effect on a dosimeter or on eggs placed at a depth of 10 cm. (11). The actual depth dose values at this level are, therefore, not much influenced by the arrangement of diaphragms, but the surface doses will vary considerably. Since depth doses are usually expressed as percentages of the surface dose, their per-

centage values will change with diaphragm conditions. Without doubt the wide variation in the surface dose values already published is due in part to this situation.

The eggs to be exposed are placed in a holder consisting of a bakelite sheet 32 × 13 × 0.3 cm. in which are cut numerous square holes. One side is sealed by a sheet of cellophane covered with beeswax. In the compartments thus formed are placed slips of filter paper carrying the eggs. The compartments are then sealed with a second sheet of cellophane and beeswax, and the holder is inverted, and held at the desired level in the phantom. The eggs, therefore, during exposure, lie on a level with the upper surface of the holder, from which level the depth is measured. The maximum length of exposure was 25 minutes. The doses, measured in air, without scatter, varied from 100 to 600 roentgens. After exposure the eggs on their slips of paper are kept in a moist chamber and counted on the second day following the exposure. In all of the experiments the conditions of exposure were: 120 kv.; 0.25 mm. Cu and 1.0 mm. Al filter; 30 cm. distance from the target to the surface of the water; half value, 0.33 mm. Cu.

RESULTS

Surface doses, and depth doses at various levels in the central beam, have been measured under square portals of 400, 225, 100, and 50 sq. cm. area. The results are summarized in Table III, and shown in graphic form in Figure 3. Each figure in the table is an average of 10 or more tests and is computed by the method illustrated in Table II. The entire series comprises more than 300 experiments. The Probable Errors of the Means indicate the degree of precision of the measurements. By adding to and subtracting from the averages given a quantity equal to three times the Probable Error, the limits between which the true biologic doses lie, may be found. Calculation will show that the values given in the table are correct within 2 or 3 per cent. In the third column of the table appear the percentage depth doses.

The latter figures agree in part with those of Grebe and Nitzge (4) which are given for comparison. Under all portal sizes the surface doses are much the same; under the smaller portals the correspondence is close at all the levels tested. Under the larger portals, the agreement is good at depths greater than 5 cm., but at lesser depths the biologic method registers values which are significantly higher than those obtained by dosimetric means.

The percentage depth doses are plotted in Figure 3, where they are expressed in logarithms. The points tend to fall along straight lines. This exponential relation,

TABLE III.—120 KV.; 0.25 MM. CU PLUS 1.0 MM. Al; HALF VALUE, 0.33 MM. CU; DISTANCE 30 CM.

400 sq. cm.				225 sq. cm.		
Depth	Depth Dose	% D.D.	Grebe-Nitzge	Depth Dose	% D.D.	Grebe-Nitzge
0	140.8 ± 0.72	100	100	133.9 ± 0.87	100	100
1	138.0 ± 0.61	98	96	130.7 ± 1.13	98	96
2	136.2 ± 1.17	97	84			
3	120.6 ± 0.57	86	75	109.4 ± 1.00	82	72
5	87.6 ± 0.81	62	58	80.4 ± 0.59	60	52
7	67.5 ± 1.00	47	45	56.6 ± 0.66	42	39
10	43.4 ± 0.72	31	30	38.9 ± 0.64	29	24
100 sq. cm.				50 sq. cm.		
0	130.2 ± 0.68	100	100	119.3 ± 0.70	100	100
1	124.6 ± 0.74	96	94	107.8 ± 1.31	90	89
3	90.9 ± 0.45	70	68	76.4 ± 1.36	64	61
5	63.5 ± 0.80	49	49	54.3 ± 0.89	46	42
7	45.5 ± 1.20	35	35			
10	27.8 ± 0.61	21	21	22.9 ± 0.95	19	18

Depth doses in a water phantom, determined by the biologic method.

first pointed out by Bolaffio (2), is found in practically all of the depth dose data obtained by investigators using both high and low voltages. The figure shows that under the large portal areas the curves drop slowly from their point of origin and become exponential below a depth of 2 or 3 cm., while under small areas they are exponential below the first centimeter of depth. If, as seems probable, this relationship is of general occurrence, the measurement of depth doses, especially under the smaller portals, is greatly simplified. Two or three determinations will establish the slope of the curve, from which can be read the correct depth doses at any intermediate points.

The biologic method has also been used to determine the distribution of x-ray intensities in the water phantom at points outside of the central axis of the beam. The experimental procedure is the same as before. Several samples of eggs are placed in compartments in the bakelite holder at various distances from the center, and irradiated simultaneously. Table IV gives data from a single experiment to illustrate the method of computing the depth doses at the different points. In this test the eggs were submerged to a depth of 5 cm., the other experimental conditions being given in the caption. In the second column are given the percentages of survival for each position; in the third, the doses in biologic roentgens which the eggs must have received to produce the observed survival rates. In the fourth column are the ratios between the biologic doses and the incident dose, which in this experiment was 284 r. In the fifth column these figures are expressed as percentages of the surface dose which, as shown in Table I, is 141 per cent. It will be seen that the percentage of surviving eggs increases rapidly as the distance of the point of irradiation from the center increases, and that the depth doses decrease correspondingly.

TABLE IV.—120 KV.; 0.25 MM. CU, 1.0 MM. Al; 30 CM. DISTANCE; 400 SQ. CM. PORTAL; 5 CM. DEPTH; DOSE 284 r

Distance from Center	% Survival	Biol. r	Ratio	% Depth Dose
0 cm	33.8	241	85	61
5	38.8	224	79	56
7	41.5	215	76	54
9	65.6	151	53	38
11.5	79.8	118	42	30

Data from a single experiment to illustrate the method of determining the distribution of x-ray intensity in a water phantom.

The results of many similar experiments at this and other depths have been averaged, and are shown in Figure 4. A comparison of the course of the isodose curves with those figured by other investigators shows that under these experimental conditions, the intensity of radia-

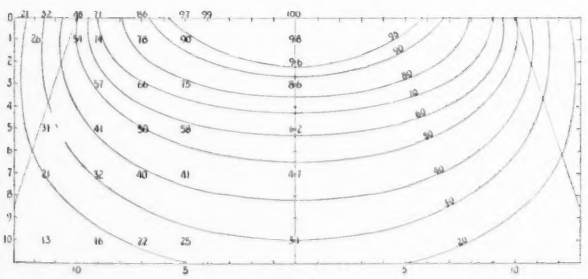

Fig. 4.

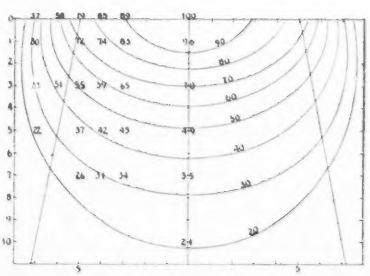

Fig. 5.

Fig. 4. Isodose chart showing the distribution of x-ray intensity in a water phantom. Area of portal, 400 sq. cm. Other conditions as in Figure 3.

Fig. 5. Isodose chart showing the distribution of x-ray intensity in a water phantom. Area of portal, 100 sq. cm. Other conditions as in Figure 3.

tion in the first five centimeters below the surface of the phantom is decidedly greater than has previously been reported. The higher depth dose values are found not only in the central beam but also at some distance from it.

Figure 5 shows the results of other experiments made under a portal of 100 sq. cm. The values of the depth doses in the central beam are approximately the same as those given by Grebe and Nitzge. The course of the isodose curves does not differ significantly from those based on dosimetric measurements.

The fact that the biologic method of measurement reveals higher intensities near the surface of the water than are shown by dosimeters calls for further examination. The total intensity at any point in the phantom consists of primary and scattered radiation. The amount of the former can be calculated from physical tables, or determined directly by dosimetric means. It follows that the lack of agreement between the results of different investigators must be due to differences in the measurement of scattered radiation.

A direct biologic measurement of scattered radiation can be made in a simple way. Two samples of eggs are placed in the bakelite holder and submerged to the desired depth. Over one is held, at a distance of 2 cm., a lead shield just large enough to cut off all direct radiation. The other sample is not covered. The first can be affected only by scattered rays coming from all parts of the phantom except the small volume of water directly above it; the second receives both direct and scattered rays. The dose that each sample receives, measured in biologic roentgens, is determined from the survival rate of the eggs. In Table V are given the results of several such tests. The ratios between the biologic doses and the incident doses appear in the last column of each section; the average value is given below. The primary intensity at each level, shown at the bottom of each section of the table, was determined by dosimeter tests in the following way. The intensity in air of a very narrow beam was first found. Then a container of thin celluloid was placed at some distance above the thimble chamber and filled with water to depths of 1, 3, 5, and more centimeters, and the beam again measured. The sum of the intensity of the primary beam at each level as thus determined and of the scattered radiation, measured biologically, almost exactly equals the total intensity, measured by the latter method. It thus appears that the large depth dose values found under the large portals are not the result of accidental variations, but that they fairly represent the biologic activity of the radiations at those levels.

TABLE V.—120 KV.; 0.25 MM. CU AND 1.0 MM. AL FILTER; 30 CM. DISTANCE; 225 SQ. CM. AREA

	With Lead Shield				Not Covered		
	Dose	% Alive	Biol. r	% Incident Dose	% Alive	Biol. r	% Incident Dose
3 cm. Depth	236	76.1	138	58.5	30.9	254	107.6
	237	62 6	158	66.7	30.1	257	108.4
	289	60.9	163	56.4	21.0	303	104.9
	289	52.9	183	63.3	18.4	320	110.8
	Intensity of Scattered Radiation			61.1	Total Intensity		107.9
	Intensity of Prim. Beam			46.0			
5 cm. Depth	175	89.8	94	53.7	68.5	144	82.3
	215	81.4	114	53.0	54.9	178	82.6
	284	78.0	122	42.9	36.8	231	81.0
	295	66.2	149	50.5	33.9	240	81.4
	298	58.8	168	56.4	41.0	217	72.8
	Intensity of Scattered Radiation			51.3	Total Intensity		80.0
	Intensity of Prim. Beam			27.0			

The measurement of scattered radiation.

DISCUSSION

The value of the biologic method of measurement is sometimes judged by the degree to which its results conform with those obtained by the use of thimble chamber dosimeters, the assumption being that the latter are substantially correct. "The problem of the direct measurement of the surface dose may now be regarded as solved," according to Holthusen and Braun (7). But the very considerable differences, recently reported, between the results of experiments to determine surface and depth dose values indicate that the problem is still unsettled.

There are several reasons for this lack of agreement. One is that there is no standardized method of taking dosimeter readings. The number and position of the diaphragms appreciably affect the apparent magnitude of the surface dose (11, 21), but these details are not often mentioned in the description of the experiments. Whether the different scattering media used, such as water, paraffin of unspecified density, unit density wax, and rice powder, are alike in their absorbing and scattering properties under different experimental conditions, has not been satisfactorily determined.

Another factor which influences the magnitude of the surface dose is the size of the thimble chamber. Parker and Honeyburne (16) point out that with chambers of large diameter the recorded doses, particularly near the surface, are also large. At a depth of one centimeter doses in excess of the surface dose may be obtained. Such values are given by Grebe and Nitzge (4) and by Holthusen and Braun (7). But with smaller chambers the intensity at this level is found to be equal to or less than that at the surface, never greater. "The nature of the variation of apparent depth dose with chamber diameter was such that the measurements with the smallest chamber diameter available appeared to be practically identical with the attempted extrapolation to zero chamber size, except possibly for depths less than 2 cm."

These factors affect to an appreciable extent the results of dosimeter measurements but they do not explain the large differences in the magnitude of the recorded surface doses when the conditions of exposure are substantially alike. For example, for a definite area and approximately the same quality of beam, and the same distance, the percentage of scatter at the surface of the phantom is given as 27 (17), 33 (7), 38 (21), and 54 (18). There is thus a difference of 100 per cent between the lowest and highest values. Another lack of agreement occurs in statements regarding the relation between the amount of scatter at the surface and the wave length of the incident beam. Quimby and Marinelli (17) find no change with increasing hardness. The range which they investigated is represented by half values in copper of 0.8 to 2.4 mm. But later Quimby and others (18) observed that the surface scatter decreases decidedly as the hardness of the beam increases. In these tests they used a special type of ionization chamber consisting of parallel threads of silk. Similar relations have been reported by Glocker and Kaupp (3), Gunsett and Nouret-tine (5), and recently by Parker (15) whose surface dose values are nearly as high as those reported by Quimby (18).

The absolute values of depth doses, reported in recent literature, also vary considerably, being large when the surface doses are large and *vice versa*. When, therefore, depth doses are expressed in the usual way, that is, in terms of the surface dose, the percentage values found by different investigators are not very different. Thus, all of the actual surface and depth doses reported by Parker (15) are much higher than those given by Grebe and Nitzge (4) and Holthusen and Braun (7), but the percentage depth doses are nearly identical except those relating to depths of one and two centimeters below the surface. This situation indicates that differences in actual dosage values are due to the dosimeters which are used. And this, in turn, again emphasizes the

fact that the methods of thimble chamber dosimetry are still far from perfect.

The results of a biologic method of surface and depth dose measurement will also be affected by some of the experimental conditions just mentioned, such as the number and arrangement of the diaphragms, and the nature of the scattering medium. But a very real advantage of using small living test objects, such as *Drosophila* eggs, lies in the fact that the eggs, which are biologic dosimeters, approach "zero size." And since they lie in a single layer during exposure, they register the actual intensity of the radiation in a plane, rather than the average intensity in a volume of scattering medium, as thimble chambers must necessarily do.

The value of a biologic method of measurement depends to a large degree on the constancy of sensitiveness in the samples of test objects used during the experiment. When the response of these samples to equal doses remains about the same day after day, the measurement will be precise and dependable. The data presented in this paper show that under satisfactory experimental conditions, the results of the *Drosophila* method are correct within ±3 per cent. When, therefore, they do not agree with those obtained by thimble chamber dosimeters, there is good reason for asserting that the biologic method gives the more correct measurement of the biologic dose.

SUMMARY

1. The response of *Drosophila* eggs to measured doses of x-rays is so constant that it can be used as a measure of dosage. A precision of ±3 per cent may be expected.

2. The procedure followed in making surface and depth dose determinations is described.

3. Under large portals (225 and 400 sq. cm.) the intensity of radiation in the first five centimeters below the surface of a water phantom is found to be higher than has heretofore been reported. This is due to the large amount of scattered radiation, which has been measured. At the surface and at depths greater than 5 cm., the intensities are not significantly different from those given by Grebe and Nitzge. Under smaller portals (50 and 100 sq. cm.) no unusually high depth dose values were found.

4. The intensity of radiation at points outside the central beam has been determined.

5. The biologic method records more accurately the biologic activity of x-radiation than does the present dosimeter method.

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THE DETERMINATION OF X-RAY QUALITY BY FILTER METHODS[1]

By LAURISTON S. TAYLOR, National Bureau of Standards, *Washington, D. C.*

WITHIN the past decade much has been written and more said about the question of the measurement of x-ray quality. It is not the purpose of this paper to propose any new method, but rather to discuss and compare the several more commonly advocated methods of quality determination from the points of view of their physical soundness and clinical application.

It is important to clarify the two principal viewpoints regarding x-ray quality. To the physicist, x-ray quality means the distribution of energy among the different wave lengths present in an x-ray beam. This distribution is not only difficult to determine, but also when known is of little or no practical value to the radiologist in solving his everyday treatment problems. On the other hand, quality to the radiologist means some descriptive index which will permit reproduction of one of the essential treatment factors, namely, the "penetration" or "depth dose." In outward appearance, these two viewpoints seem widely separated, but it must be obvious that both have a parallel bearing on the problem under consideration in that each characterizes the same property. Since it is the radiological problem that concerns us, we will discuss quality from that viewpoint, and at the same time endeavor to explain its foundation on sound physical concepts.

The spectral energy distribution of x-rays is fixed by the value of the exciting potential at the particular instant in question. Thus, for constant potential excitation, the spectral distribution is the same at all instants, since the tube voltage is not changing with time. For a fluctuating potential, the spectral distribution is changing cyclically and the average or effective distribution over a complete cycle can be calculated only with difficulty. Its experimental determination is practical only with a crystal spectrometer. However, for the same voltage wave form the average spectral distribution will remain constant.

Hence, the radiologist's "quality" problem would be solved (or rather eliminated) if it could be universally agreed to use the same exciting wave form—an impossible solution for practical reasons. On the other hand, constant excitation voltage is easily producible universally, and hence by its means quality standards may be established and reproduced at will. It is not meant to imply that only constant potential should be used clinically but to point out a possible (if perhaps undesirable) solution to the problem of measuring x-ray quality. X-ray excitation by pulsating voltages has its practical advantages and will always be present—accompanied by the problem of specifying the radiation quality from the "reproduction" point of view.

It may be well to emphasize at this point that quality specifications which involve a description or approximation of the voltage wave form are akin to lifting oneself by the bootstraps. For, as shown in the two preceding paragraphs, quality description is necessitated solely through our inability to utilize a knowledge of wave form even when available. X-ray quality standards have been grouped by some into two classes with respect to the excitation: constant potential and valve rectified potential. The former is definite. The latter may include, as extremes, half-wave on an ordinary tube and half-wave on a special tube with a strongly biased filament. The filament bias may be adjusted to give a quality nearly the same as that of constant potential at the same peak value, whereas the simple half-wave will produce a much softer radiation having less average pene-

[1] Publication approved by the director of the National Bureau of Standards of the U. S. Department of Commerce.

tration. Other wave forms frequently used will give intermediate qualities.

Most quality determinations, aside from actual spectrometric measurements, are made through a series of absorption measurements in filters of a given material placed in the unknown x-ray beam. Here, the problem is complicated by the fact that true energy measurements are not made on the x-ray beam, such being impractical without very elaborate apparatus and technic. Instead, we measure the radiation in terms of the amount of ionization the beam produces in a gas. This is proportional to the fractional part of the radiation absorbed in the gas, which in turn, for a given gas, varies with the wave length of the radiation and varies between gases for the same wave length. The term "dosage rate"[2] refers to the ionization chamber measurement, with air as the standard gas. Air is chosen for the reasons that it is most conveniently available, is reproducible, and has an effective atomic number near that of body tissue. It should be borne in mind, therefore, that any experimental determination of quality embodies all the above factors and, hence, to a considerable extent depends upon an arbitrary agreement as to the choice of experimental technic. Different technics involving different filter materials or different ionization chamber gases will, in general, give varied results which are usually incapable of ready correlation.

Full Semi-logarithmic Absorption Curves.—A full set of absorption data—usually given in the form of a curve showing dosage rate as a function of the filter thickness—presents the maximum information made available by the filter method of measuring x-ray quality. Having this, it has been shown theoretically (11) for constant potential excitation and checked experimentally (2), that any given spectral distribution has a particular absorption curve and that no two different spectral distributions can give identical absorption curves. These studies have provided the desired relationship between the quality specification as conceived by the physicist and required by the radiologist.

Strictly speaking this applies only to constant potential, but it has been conclusively demonstrated (13) that a fluctuating potential produces an average spectral distribution whose absorption curve matches within practical limits, that obtained at some particular constant potential. It must be admitted, however, that if carried out to an excessive degree of filtration, such curves must diverge, since one beam will contain wave lengths shorter than any present in the other beam. But there are practical limits beyond which it is unnecessary to extend the filtration measurements. These limits differ with the different practical applications of the radiation, and by international agreement, the maximum filtration—assumed in all further discussion—is specified as the amount which will reduce the dosage rate to 1 per cent of its incident value.

For convenience, the percentage transmission rather than relative transmission may be plotted so that all curves pass through the same point for zero filter. A further convenience is obtained by plotting the logarithm of the percentage transmission against filter thickness, which compresses the vertical scale and has the additional value that absorption coefficients may be obtained directly from the slope.

We have shown (13) for constant potential excitation that a semi-logarithmic absorption curve is characterized by the voltage and filtration and that curves differing in initial filtration may always be brought into coincidence through a combined shift parallel to the ordinate and abscissa—the abscissal shift giving directly the filtration difference. It was also shown that within reasonable limits an absorption curve produced by whatever excitation may be brought into coincidence with some specific constant potential curve by suitable shifts on both axes. The comparisons were made

[2] "The x-ray dosage rate at a point in an irradiated medium is the x-ray dose (measured in roentgens) received per unit time at the point in question." From joint memorandum by N.B.S., N.P.L., and P.T.R., 1934.

for constant and pulsating voltages up to 200 kv. with filtrations never in excess of 3 mm. of copper, and hence include only conditions ordinarily encountered in the therapeutic application of x-rays. Carried to higher filtrations, the absorption curve for the pulsating voltage begins to rise above that for constant potential. However, this portion of the curve for pulsating potential may be readily matched with some other higher constant potential curve and hence may be adequately described in terms thereof. Within the 200 kv. range it has been found that, so long as that filtration does not reduce the dosage rate to less than about 5 per cent of the zero filter value, matching of the absorption curves over their full length is possible. *These studies proved that an adequate quality designation would be given by a statement of the fore-filter and equivalent constant potential.*

The important fact to be borne in mind here is that a full semi-logarithmic (or other derived) curve gives a complete description of a given beam of radiation, and that the accuracy of that description may be carried out to any desired degree by merely increasing the range of filtration and the accuracy of the measurements.

It is, of course, obvious that for many purposes obtaining a full absorption curve is unwarranted by the required accuracy of the experiment; and it is for that reason that numerous other shorter methods have been proposed and used. In the discussion which follows we wish to make clear that all these other methods are in reality, only partial descriptions of a full absorption curve, and that their degree of accuracy in describing a curve depends entirely upon the choice of technic.

Half Value Layer (h v l).—By half value layer or half value thickness is meant the thickness d of filtering material required to reduce the incident dosage rate I_0 to a transmitted value $I_{1/2} = .5I_0$. This may be written as $\log I_{1/2} = \log I_0 + \log .5$ or $\log \frac{I_{1/2}}{I_0} = .301$.

From this it is evident that on the semi-logarithmic absorption curve, the half value for any initial radiation whatever gives two points on the absorption curve which differ always in ordinate by .301. Thus, referring to Figure 1, if a represents the initial radiation, and b the point whose ordinate is less than a by .301, then the abscissa difference gives the half value layer at once.[3]

It is obvious that having but two points, the curve is not fixed. Although knowledge of the general form of x-ray absorption curves does limit the choice somewhat, this, to be of value, must, in addition, have the voltage as well as the initial filtration stated, to definitely fix the quality or the proper absorption curve. To overcome this difficulty, it has been proposed to use two half value layers to express the radiation quality (5). As indicated in Figure 1, the second half value layer d_2 fixes a third point c on the curve, which differs in ordinate by a constant value of .602 from the initial point a. Three points, of course, would much more nearly fix the curve; but, after all, the number of experimental observations required to fix these three points is sufficient for establishing a full absorption curve. In addition to the three points at least a rough curve must be plotted for interpolation purposes; so that for a single half value layer determination, a minimum of three and an average of five measurements must be made.

To express quality by the "two half value layer" method, two numerics must be given. Unfortunately ratios or differences between the first and second half value layers lead to multi-valued functions so that there does not appear to be any simple way of reducing to a single number the radiation quality determined in this manner. It can be done by relating the numbers through a particular absorption curve which may, in turn, be expressed in

[3] This suggests a very simple method for reading half value layers from semi-logarithmic absorption curves. A piece of cross-section paper is cut in the shape of an elongated L and graduated on the same scale as the plotted curves. By simply placing A on the curve at any desired point, the half value layer is read off directly on the abscissa scale.

some form of equivalent potential. The process is too laborious to be seriously considered.

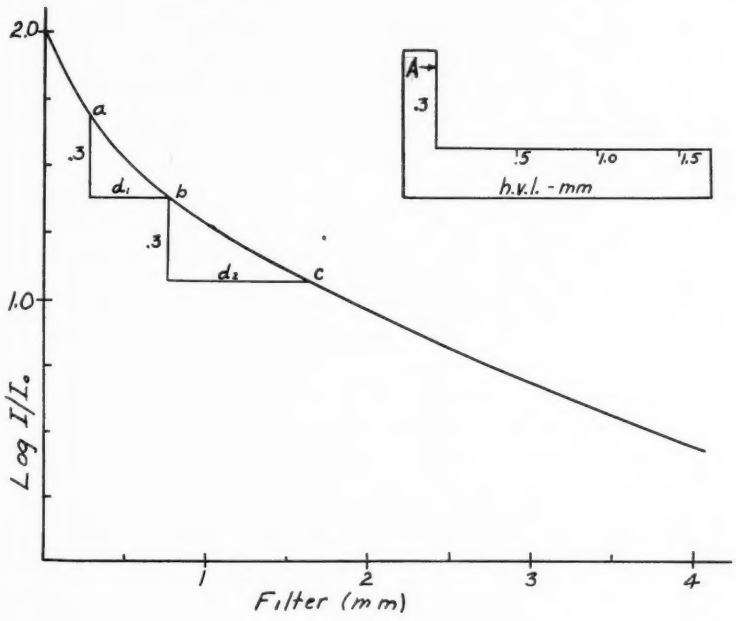

Fig. 1.

Half value layer measurements offer the advantage of depending only upon the kind of filter used and not upon a specific thickness, as in the case of the effective wave length (Duane, 3, 4).

In common with all the approximate methods of quality determination, the sensitivity of quality differentiation by means of the half value layer varies considerably between the low and high filtrations at a given voltage or low and high voltages for a given filtration. This lack of sensitivity might be overcome by using, say, $^3/_4$ or $^1/_5$ value layers, although, because of the added complication, this step is probably unwarranted.

Families of curves and nomograms have been set up by which means one can determine the half value layer from the voltage or filtration for both constant and pulsing potential (5, 2). The former is quite definite, but for pulsating potential the procedure is risky, since so many wave forms are possible; for example, Witka, Villard, mechanically rectified, or biased filament voltages.

Effective Wave Length.—The effective wave length (Duane) of x-rays (3, 4) is given by the wave length of the monochromatic radiation which is absorbed in a given filter to the same extent as the heterogeneous beam in question. From the simple absorption law we have

$$\log \frac{I}{I_0} = -\mu x$$

$$\log I_0 - \log I = \mu x$$

where μ is the absorption coefficient and x is the filter thickness.

For monochromatic radiation this is a straight line of slope μ when $\log \frac{I}{I_0}$ is plotted against x. Referring to the heterogeneous absorption curve in Figure 2, we have μ

given by ad/x_1 for a given filter thickness x_1. Using this value of μ, the effective wave length λ_e is obtained from the empirical monochromatic wave length absorption curves or equations (9, 10).

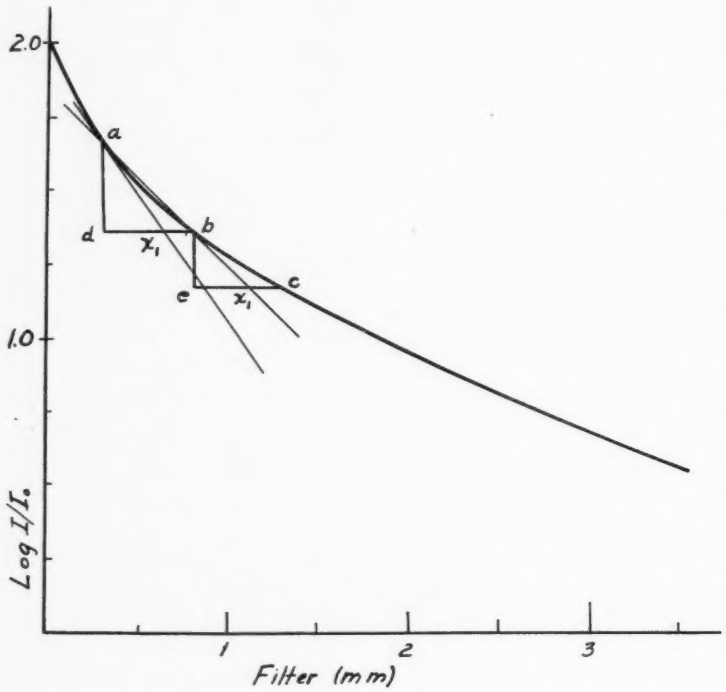

Fig. 2.

Reduced to its fundamental significance, the effective wave length gives two points on an absorption curve separated always by a constant abscissa (as compared with a constant ordinate separation in the case of the half value layer). As proposed by Duane, the radiologist avoids the step involving use of the absorption laws and by means of computed curves is able to read directly the effective wave length in terms of the ratio of incident to transmitted dosage rate through a given filter.

Since this effective wave length is determined by the slope of a secant between two points on the absorption curve, it is obvious that it does not correspond to the absorption coefficient at either end point but to some intermediate point, the relative position of this latter point depending upon the position along the curve where the measurements are made.

The great advantage of this method lies in the fact that only two measurements are required. It has, however, suffered the unfortunate disadvantage that there has been a widespread use of various filter thicknesses and material in the measurements, each of which yields a different result, which is not easily co-ordinated with the others except through use of the full absorption curve. To add to the misfortune, it was only rarely that an author took the trouble to state just what material and thickness was employed in his measurement.

To specify a third point on the absorption curve, we might use a "second effective wave length" in just the same manner

as a second half value layer, but with the very considerable advantage that only three measurements would be required as compared with at least seven by the other.

An attempt was made as in the half value layer case, to find a simple method of combining a first and second effective wave length into a single numeric, but this also always developed into a multivalued function and hence was not permissible.

Other effective wave length methods involve the determination of the full absorption curve. These have been designated as average wave length (7) or as true effective wave length (12), although in reality both are the same except that the former deals with portions of the absorption curve which are supposedly "straight." Since this is not physically possible in the ranges covered, it is perhaps better not to use the term "average."[4]

These methods yield the absorption coefficient at a single point on the curve from the slope of a tangent at that point, as shown in Figure 2. (This corresponds to the use of an infinitesimal filter in the Duane method.) Thus instead of giving two points on an absorption curve, these last methods yield one point and slope at that point. The two sets of conditions are about equally effective in designating a particular curve. The true effective wave length method has the slight advantage over the Duane effective wave length in that it involves the absorption coefficient at a point on the curve corresponding to some particular filter, whereas Duane's method involves some unknown point. For highly filtered radiations this is far less important than for moderately filtered radiations (less than 0.5 mm. Cu at 150 kv.). Since in any case both methods are but approximations to a full absorption curve, it is probable that the simplicity of Duane's method offsets this disadvantage.

It may be well to point out that the term "effective wave length" has very little physical significance. Effective wave length is a matter of definition only and its significance in relation to other quantities (for example, absorption in water) depends entirely upon the choice of filters used in its determination. Consequently, we may reasonably question the value of its use and raise the question: Why not stop at the absorption coefficient stage in the calculations? This would give a term (effective absorption coefficient) which, while having no more ultimate significance than effective wave length, would not tempt unwarranted interpretation or uses of the latter.

Absorption Coefficient.—Newell[5] has pointed out that use of the absorption coefficient permits an easier matching of absorpiton data (as, for example, a full curve). As the radiation becomes harder, the absorption coefficient tends toward a constant value. Consequently, if the derivative of a full absorption curve be plotted—thus giving an absorption coefficient curve—it is found that at the higher filtrations the curve approaches the horizontal more rapidly and that a match between curves apparently need be made in the ordinate dimension only.

This method permits a more accurate identification or matching of absorption curves *in the regions of high filtration.* It does, however, essentially neglect the portions of the curve corresponding to low filtrations, since the absorption coefficient is

[4] Authors frequently refer to the "straight portion" of a semi-logarithmic absorption curve. It has been shown (13) that under ordinary conditions (copper up to 300 kv., aluminum up to 150 kv.) such a straight portion must be due to some experimental error, wall effect in thimble chambers being the usual cause. Consideration of the simple laws of filtration will show that a heterogeneous beam cannot be made homogeneous until all but the minimum wave length are filtered out. At the higher voltages "straight portions" may be caused by the use of a filter which is too transparent to all wave lengths comprising the radiations used. For example, aluminum used at 500 kv. would yield an approximately straight curve which might be interpreted as due to homogeneous radiation. However, this would mean only that the aluminum was so transparent to all the wave lengths that there was effectively no difference in the absorption between the longest and the shortest wave lengths, while actually the radiation was changing its quality with each change in filtration.

[5] Unpublished paper presented at American Physical Society, June, 1936.

changing so rapidly as to make any matching along the filter axis extremely difficult. This may be compared with the matching of the full absorption curves directly, which can be done with much greater ease at the lower filtrations than for the higher.

A greater advantage of the absorption coefficient for identifying radiation quality lies in its permitting the use of tabular data giving the absorption coefficients at certain filtrations under standard conditions which may be used for direct identification of unknown radiations having the same initial filtrations. However, when considering the various steps involved, it is difficult to see where this method offers any outstanding advantages over the effective wave length methods.

Quality of High Voltage Radiation.—The foregoing discussion is equally applicable to the determination of the quality of radiations produced by potentials in excess of 250 kv. We ordinarily find, however, that high filtrations are used at these voltages and that the curvature of the absorption curve is very much less than at lower voltages. (This varies with filter material but holds true for the filter-voltage combinations in ordinary use.) This means that no great error will be encountered in defining a particular curve by means of two points, by whatever of the above methods they might be determined. It means further that thus there is certainly no need for such measurements as a second half value layer. So long as the filter material is suited to the particular voltage range, no serious error will be involved in using any of the well-known quality measurements.

Discussion of the choice of filter material is not necessary here since it has been critically discussed by Holthusen, Mayneord, Quimby, Thoraeus, Newell,[6] and others (5, 6, 8, 14).

[6] *Loc. cit.*

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DIFFERENTIAL DIAGNOSIS OF BONE TUMORS OF THE EXTREMITIES BY ARTERIOGRAPHY

By P. L. FARIÑAS, M.D., *Havana, Cuba*

At the Fourth International Congress of Radiology, in Zurich, José P. Caldas, of Lisbon, presented a most interesting paper, namely, "Radio-diagnosis of Bone Tumors by Arteriography." It led us to start studying by arteriography the circulation in the bone lesions with Dr. M. Robau and Dr. L. Fariñas. It is needless to point out the great importance of a method that helps in the early differential diagnosis between benign and malignant bone tumors. Arteriography is a procedure that is applied to the patient easily, without danger, and helps materially in the diagnosis.

The technic is simple. After local anesthesia a direct punction of the artery is made. When the sub-clavicular artery is injected, it has to be exposed, and the same applies to other arteries of the extremities when they are not easily punctured.

According to the region, from 5 to 20 c.c. of thorotrast is injected, and immediately radiographs are taken in rapid succession.

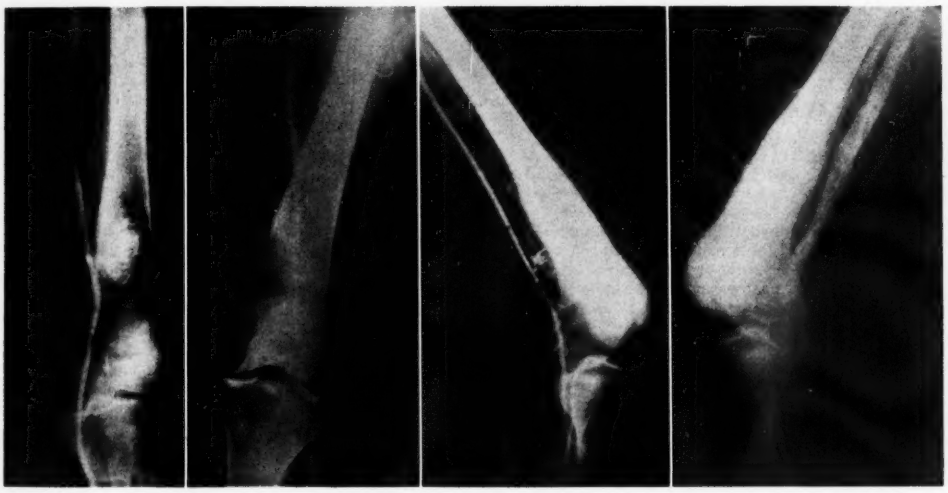

Fig. 1. Fig. 2. Fig. 3-*A*. Fig. 3-*B*.

Fig. 1 Case 1. Arteriography: Direct punction of the femoral artery. Injection of 12 c.c. of thorotrast. The arteriogram shows slight displacement of the femoral artery by the tumor. No neoformating vessels can be seen. Benign bone tumor. Biopsy: Chondroma.

Fig. 2. Case 2. Benign giant-cell tumor. History of repeated trauma at the right knee. Palpable tumor with pain and local heat. Radiography shows osteolytic tumor involving the metaphyseal and epiphyseal side of the inferior end of the femur. The epiphysis has trabeculararan aspect. The question of osteolytic sarcoma or benign giant-cell tumor arose.

The arteriogram shows marked compression of the femoral artery by the tumor; lack of intra-tumoral circulation; a very fine artery follows the capsule of the tumor. The diagnosis of giant-cell tumor was established. Biopsy showed giant-cell tumor.

Fig. 3-*A*. Case 3. Ewing tumor. Patient is 16 years of age. Fever and pain at the lower end of the femur. Radiograph shows an osteoblastic tumor involving the lower half of the shaft of the femur. There is expansion of the shaft and onion-peel deposit of periosteum. Diagnosis: Ewing tumor or osteomyelitis of Garré.

The arteriogram shows three broad vascular pedicles of the tumor and many new vessels running in all directions. At the border of the tumor new arteries perpendicular to the bone can be seen. There the bone spicule will be laid down later, giving the sunburst aspect. Diagnosis: Malignant tumor. Biopsy showed Ewing tumor.

Fig. 3-*B*. Case 3. The venous circulation shows irregular distribution of the new vessels with neoplastic aspect.

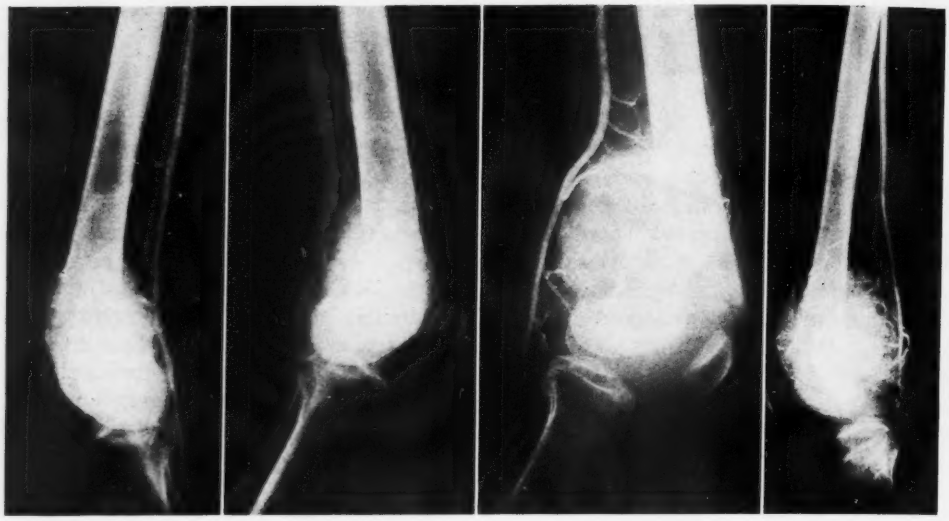

Fig. 4-*A*. Fig. 4-*B*. Fig. 5. Fig. 6-*A*.

Fig. 4-*A*. Case 4. Sarcoma. Patient is 18 years of age. History of trauma. Pain in lower part of femur that has increased lately. Palpable tumor. Radiograph shows sclerosing type of tumor with the aspect of sarcoma.

The arteriogram shows several vascular pedicles; an atypical circulation with new vessels running in all directions, giving the tumor a shadow beyond the bone. Diagnosis: Bone sarcoma.

Fig. 4-*B*. Case 4. The venograph shows large femoral vein and irregular network of venous vessels at the tumor area, characteristic of malignancy. The venous circulation appears rapidly in the series of films—characteristic of sarcoma (Caldas). Biopsy: Osteogenetic sarcoma.

Fig. 5. Case 5. Bone sarcoma. The radiograph shows the typical aspect of osteogenetic sarcoma with pathological fracture.

The arteriogram shows several arterial pedicles of the tumor and many irregular new vessels characteristic of malignancy. Biopsy: Osteogenetic sarcoma.

Fig. 6-*A*. Case 6. Bone sarcoma. The x-ray film shows the characteristic aspect of osteogenetic sarcoma.

The arteriogram shows several vascular pedicles supplying nutrition to the tumor and an irregular network of newly formed arteries running in all directions and showing the tumor in the soft tissue.

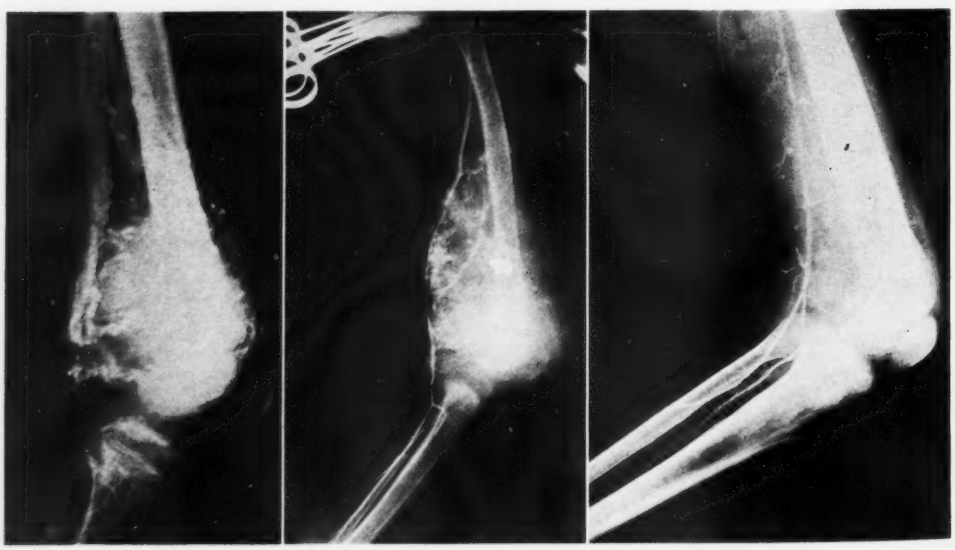

Fig. 6-*B*. Fig. 7. Fig. 8.

Fig. 9. Fig. 10-*A*. Fig. 10-*B*.

Fig. 9. Case 9. Ewing tumor. The patient is 12 years of age. The x-ray film shows the characteristic aspect of a malignant tumor of the femur.

The arteriogram shows a typical anarchic circulation characteristic of the neoplastic processes.

Fig. 10-*A*. Case 10. Malignant metastasis. The patient is 35 years of age. Removal of the left breast for tumor; bone metastasis at the sternum and right femur. The x-ray film shows an extensive malignant metastasis of the femur, osteolytic in character with destruction of the periosteum and invasion of the soft tissues.

Arteriogram shows direct punction of the femoral artery after local anesthetic. Injection of 12 c.c. of thorotrast. The films show several vascular pedicles, an intricate network of new vessels, running in all directions, of about the same caliber, and characteristic of malignancy.

Fig. 10-*B*. Case 10. The venograph shows increased venous circulation. Many irregular new vessels in the tumor area that make the tumor show plainly in the soft tissues.

In order to obtain the best contrast of the circulation, it is necessary to make a good compression of the artery above the point of injection, and at times it is practical to do the same below the lesion. After the first plate has been made, the compression is released and other films are taken to show the returning circulation (venography). From the study of these films we may obtain much information relative to the nature of the tumor.

In benign tumors the vessels may be dis-

(*See illustrations on opposite page.*)

Fig. 6-*B*. Case 6. The venograph shows anarchic vein circulation. Here, as in the arteriograph, small vessels perpendicular to the shaft (sunburst) can be seen.

Fig. 7. Case 7. Osteogenic sarcoma (telangiectatic). Patient is 5 years of age. Two months previously there was a trauma to the knee followed by an increasing tumor. The x-ray film shows the characteristic aspects of osteogenic sarcoma.

The arteriogram shows compression and displacement of the femoral artery by the tumor and an anarchic network of newly formed vessels in the tumor, characteristic of sarcoma. Here the character of the circulation gives a mottled aspect of the telangiectatic tumor, due to the deposit of thorotrast in the vascular sacs of the tumor.

Fig. 8. Case 8. Diagnosis between chronic osteomyelitis and Ewing tumor. Patient, 35 years of age, complained of pain in the inferior third of the femur. Lately the pain has increased, and there is swelling and fever. The radiograph shows expansion of the shaft by new bone formation. Periosteal reaction with onion-peel aspect. The arteriograms show ischemic aspect of the circulation in the affected area. Arteriographic diagnosis: Chronic osteomyelitis, proved by operation.

placed by the newgrowth, but they are regular in caliber and number (Case 1).

The giant-cell tumors do not show intratumoral circulation, but we see an artery following the capsule (Case 2).

In malignant tumors we observe several vascular pedicles nutritioning the newgrowth and an irregular network of newly formed vessels of the same caliber running in all directions (Cases 3–6). Among the group of sarcomas we may differentiate some special types, such as the telangiectatic tumors, by the character of their circulation; multiple pedicles, an extended network of newly formed vessels running in all directions, anarchic in character, a special characteristic of these tumors being a mottled aspect due to intratumoral vascular sacs (Case 7).

At times it is very difficult to make a differential diagnosis between chronic osteomyelitis and some malignant tumors, such as Ewing's. In such cases arteriography is a method of great importance in differentiating. In chronic osteomyelitis we see a decrease in the number and caliber of the arteries due to ischemic process; on the contrary, in the Ewing's tumors we see the characteristics of the neoplastic tumors (Cases 8 and 9).

The metastatic malignant tumors show the same characteristic anarchic circulation (Case 10).

GANGRENE OF FACE PRODUCED BY LYMPHOSARCOMA

By E. M. SHEBESTA, M.D., *Detroit, Michigan*

From the Radiologic Services of Dr. Stevens, Dr. Jarre, and Dr. Hasley, Grace Hospital

THIS paper was considered worthy of publication because of the confusing manifestations which this case presented. We have been unable to find in the literature a description of a similar case. However, Craver and Copeland (2) mention that one of their cases had involvement in the maxilla, and Schreiner and Herger (9) mention that one of their cases had involvement of the nose and two, involvement of the nose and antrum.

Craver and Copeland (2) studied 164 cases of lymphosarcoma at the New York Memorial Hospital, of which 17 revealed bone involvement. According to their studies, the bones involved in order of their frequency were: spine, pelvis, skull, femur, humerus, tibia, scapula, mandible, fibula, and ribs. All of their patients except one had lymph node involvement prior to demonstrable bone changes. Our case revealed no lymphadenopathy for several months following the onset of his symptoms.

Case Report.—A white male, aged 33, dated his illness to November, 1935, when he noticed a swelling in his nose accompanied by a profuse, foul-smelling, gray-colored, watery discharge. Because of this profuse nasal discharge, he was unable to keep his job as a city bus driver. In January, 1936, he was referred to a surgeon for relief of the marked nasal obstruction. The benefit in this instance was of extremely short duration, and in March, 1936, further resection was necessary. Following this second operation, the disease appeared to progress very rapidly. In June, 1936, he was admitted to the University of Michigan Hospital, and referred to the Otolaryngology Department. Dr. A. C. Furstenburg, Professor of Otolarynogology, was kind enough to send us the following summary of their findings:

"Our examination was as follows: The left ear was negative. The right tympanic membrane was largely destroyed, but the tympanum was dry. The nose showed the right chamber to be full of mucus. The left nasal chamber was full of pus and crusting. The mucous membrane of the inferior turbinate was granulomatous. Bare bone was felt with a probe on the lateral wall of the nose. The nasopharynx showed a swelling of the soft tissues almost filling the left posterior choana. In the mouth, the mucous membrane was destroyed over the left half of the hard palate and alveolar ridge, covered with slough, and when removed showed bare bone. The face presented a swelling over the left cheek and eye, very tender to palpation. We advised admission to the hospital for further observation and investigation.

"The blood Kahn was negative. A complete blood analysis was essentially normal, except for a mild leukocytosis of 14,000 white blood cells. X-ray examination was as follows: 'Minimal thickening, mucous membrane lining, right maxillary sinus. Clouding of left maxillary, left ethmoid and left sphenoid sinuses. Apparent increase in soft tissue, left nasal chamber. Suggestive evidence of increase in soft tissue, left margin of nasopharynx, extending laterally in an area posterior and inferior to left maxillary sinus. No demonstrable bony destruction. Tuberculous scars, both upper lung-fields, probably inactive.'

"The patient was seen by the Department of Dermatology and the lesion was thought to be neoplasm, but the possibility of a gumma or rhinoscleroma was also suggested. Biopsy specimens from the nose and mouth were reported as follows: 'Destructive ulcerating process. Necrosis of bone. Productive osteomyelitis. Heavy plasma cell changes. Obliterative changes in some of the blood vessels. The appearances are those of an ulcerating granuloma rather than neoplasm, although we cannot exclude the possibility of an underlying neoplastic disease. The biopsy specimens show primarily inflammatory lesions and upon these we make a presumptive diagnosis of ulcerating destructive syphilis.' Not satisfied with the first biopsy, another was taken and was reported as follows: 'This second biopsy shows the same changes as the preceding specimen, and, in addition, somewhat further away

from the ulcerating surface, there is an undoubted neoplasm which is the underlying pathology. This is a round-celled neoplasm with abundant stroma. The cells are largely lacking in differentiation. As far as histological evidence goes, it might be a reticulocytoblastoma or an undifferentiated cell carcinoma. We favor the second interpretation.'

"During the patient's stay in the hospital, he remained quite comfortable, and received treatment of saline throat irrigations frequently during the day. We believe this lesion of the maxilla and nose is a carcinoma and obviously the prognosis is quite poor."

Fig. 1. Fig. 2.

Fig. 1. Note the marked swelling over the left side of face and the beginning ulceration. A very foul odor accompanied the condition.

Fig. 2. This shows the patient two weeks later. The swelling subsided considerably after roentgen therapy but note that the ulceration has progressed and that a marked adenopathy has developed. Two months later the pharynx was visible through the gangrenous cheek.

On June 26, 1936, the patient was referred to Dr. Rollin H. Stevens, at Grace Hospital, for roentgen therapy. Our findings at that time were very similar to those mentioned above by Dr. Furstenburg, except for the presence of more swelling over the left side of the face. Roentgen examination of the facial bones at this time revealed a picture similar to that mentioned above, but in addition, one noted a slight degree of erosion of the floor of the left maxillary sinus and complete opacity of this maxillary sinus. At that time, there was no ulceration of the face, but there was marked inflammatory reaction over the left cheek and the left half of the nose. The patient had a temperature of 100° F.; leukocyte count was 15,000 with 80 per cent polymorphonuclear leukocytes. He complained of a mild degree of pain over the left cheek. On admission, he was given 123 r to the left side of the face, employing a 20 × 20 cm. cone; F.S.D. 50 cm.; 200 kv.; 25 ma.; filter 2 mm. Cu, plus 1 mm. Al, at the rate of 24.5 r per minute, measured with back-scatter. We believed we were dealing with an inflammatory condition rather than a neoplasm, and the patient improved markedly following the first treatment; that is, there was apparently complete disappearance of the inflammatory reaction. However, two days later we noted a lesion approximately 1 cm. in diameter over the left cheek, adjacent to the ala nasi, which suggested the presence of a furuncle. A gumma was strongly suspected. However, the blood Kline, Eagle, and Kahn tests were all negative on several examinations. The patient was given similar roentgen treatments on July 2 and July 7. Nevertheless, the ulceration of the face progressed very rapidly. Figure 1 shows the patient's face six days following admission. On July 2, we were able to pal-

pate a definite lymphadenopathy in both submandibular regions. This was thought to be an adenitis rather than a metastatic involvement. Following the administration of approximately 600 r units (measured with back-scatter) over a period of 17 days, employing the same factors as mentioned above, the adenopathy subsided. This led us further to the belief that we were dealing with an inflammatory condition. During the next five weeks the patient was given approximately 75 r to the face at weekly intervals, but the marked necrosis continued rapidly in spite of the roentgen therapy. At no time did the ulceration over the face show anything but a sharp, smooth border very similar to that of a gumma. The patient became progressively more toxic, and on September 9 began to show evidence of pneumonia over the left lower lobe, with râles over the right upper lobe. On Sept. 11, 1936, he expired.

Autopsy.—The significant findings were as follows (Dr. C. I. Owen, pathologist):

"External description: The patient was markedly emaciated and cachectic. The left side of the face, including the cheek and all of the maxilla, was gangrenous so that the pharynx was clearly visible through the cheek. The eyelids on the left side were swollen.

"The other positive findings were as follows: There was necrosis of the floor of the left orbit. There was a mass, approximately 7 cm. in diameter, firmly adherent to the left mandible, which proved to be metastatic involvement in a lymph node. The right lung revealed pneumonitis in the upper lobe and the upper portion of the lower lobe was adherent posteriorly. The left lower lobe showed massive consolidation. In the abdomen the lymph nodes were enlarged. The liver exhibited irregularly shaped grayish areas which proved to be metastatic nodules. Lymphadenopathy was also present in the inguinal region, but these nodes were only about the size of a pea.

"Microscopic: The lymph nodes exhibited almost complete necrosis. A loose fibrillary stroma remained with cells of the reticulum-cell type irregularly scattered throughout the tissue. Apparently it was the tumor tissue that was necrosed. The spleen was not involved in the process. The liver exhibited much degeneration of the parenchyma. It contained tumor tissue which was unencapsulated and which had a fibrillary stroma associated with it. The tumor cells were somewhat anaplastic, had hyperchromatic cells, little cytoplasm, and included a few mitotic figures.

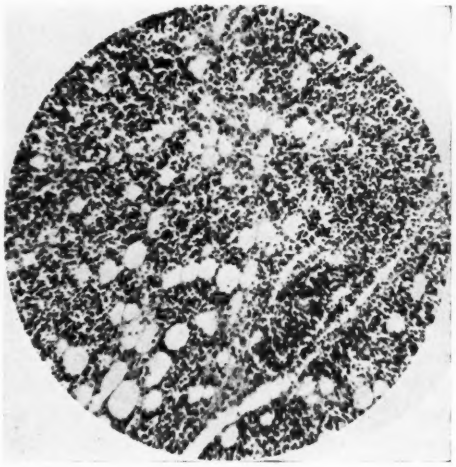

Fig. 3. Section from a large metastatic nodule which is visible in Figure 2. Note the small round cell infiltration.

Tumor tissue of a similar type was present in the skin and involved both the subcutaneum and epidermis.

"Pathological diagnosis: Lymphosarcoma, general in lymph nodes and involving liver and spleen. Gangrene of the left side of the face."

Comments.—In spite of two biopsies, the correct diagnosis in this case was not made until autopsy. The biopsies were taken from the nasal turbinates. The diagnoses strongly considered were syphilis, rhinoscleroma, reticulocytoblastoma, carcinoma, and mycotic infection. Clinically, we regarded this as an infection rather than a neoplasm, and consequently the condition was under-treated. It seems most likely that the disease originated in the maxillary sinus and next involved the nasal structures. Unlike the usual case of lymphosarcoma, the lymph nodes were not palpable until after the face showed gangrene. Craver and Copeland (2) found metastatic lymph node involvement in all but one of their 17 cases prior to the bone changes.

Summary.—A case report was presented, which showed extensive gangrene of the face produced by lymphosarcoma. The primary manifestations were nasal obstruction and nasal discharge. The neoplasm apparently originated in the maxillary antrum. The lymph nodes were not involved until late in the disease. Correct diagnosis was not established in spite of boipsies.

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MILIARY CALCIFICATIONS IN THE SPLEEN

By THEODORE M. BERMAN, M.D., *Minneapolis, Minn.*

From the Department of Radiology, University of Minnesota and University Hospital

CALCIFICATION in the spleen is an occasional incidental finding in roentgenograms of the abdomen. As might be expected, the etiologic factors are numerous. Larger areas of calcification measuring up to from two to three centimeters in diameter are uncommon and may be caused by echinococcus cysts, old infarcts, healed abscesses, rarely by bone-forming metastases, and the so-called primary tuberculosis of the spleen occurring in young adults. In the latter disease, marked splenomegaly associated with large granular areas of calcification constitutes a pathognomonic picture (4).

The usual calcification observed in roentgenograms of the spleen is the multiple, miliary form presenting numerous small rounded densities averaging from three to five millimeters in diameter. This is the type that will be considered in the present paper. Phleboliths (calcified venous thrombi) and tubercles are the most frequent causes, with calcifying hyaline perisplenitis a rare factor. There is a general opinion that these densities represent the end-results of calcified miliary tuberculosis of the spleen. In some instances, perhaps, too much importance has been attached to this finding because of the implications inherent in the presence of tubercles anywhere in the body. Clarification of the origin of such shadows is, therefore, highly desirable.

There has been a lively controversy in the German literature as to the nature of these densities. Barsony and Schütz (1), in a convincing study, radiographed 180 spleens from a series of unselected autopsies and found seven cases of miliary calcification, an incidence of almost 4 per cent. All were 50 years of age or older. Histologic study in each instance revealed the calcifications to be phelboliths of the splenic veins.

TABLE I

Case	Age	Sex	Chest Roentgenogram	Clinical History of Tuberculosis	Autopsy	Probable Etiology of Calcification
1.	13	F	# Multiple	None	No	Tuberculosis (?)
2.	28	M	N	None	No	Doubtful
3.	29	F	## Quiescent	None	No	Tuberculosis (?)
4.	35	M	## Quiescent	Urogential tract	No	Tuberculosis (?)
5.	35	M	#	None	No	Doubtful
6.	40	M	#	None	No	Phleboliths
7.	46	M	# and ## Calcified	None	No	Tuberculosis (?)
8.	48	M	#	None	No	Phleboliths
9.	49	M	O	None	No	Doubtful
10.	51	M	O	None	Yes	Phleboliths
11.	56	F	#	None	No	Phleboliths
12.	62	M	# (by autopsy)	None	Yes	Phleboliths
13.	67	F	N	None	No	Phleboliths
14.	68	F	N	None	No	Phleboliths
15.	68	M	N	None	No	Phleboliths
16.	73	F	# (by autopsy)	None	Yes	Phleboliths
17.	82	M	N	None	No	Phleboliths
18.	88	M	#	None	No	Phleboliths

#, Calc. primary focus.
##, Adult tuberculous lesion.
N, Normal lungs.
O, No film made.

Courtin and Duken (2), working with pediatric material, found miliary calcifications in the spleen associated with active tuberculosis in other organs. They interpreted these as tuberculous in nature and

were able to obtain microscopic proof in one autopsied case. Few other histologic studies have been made, and in the American literature very little has appeared on this subject.

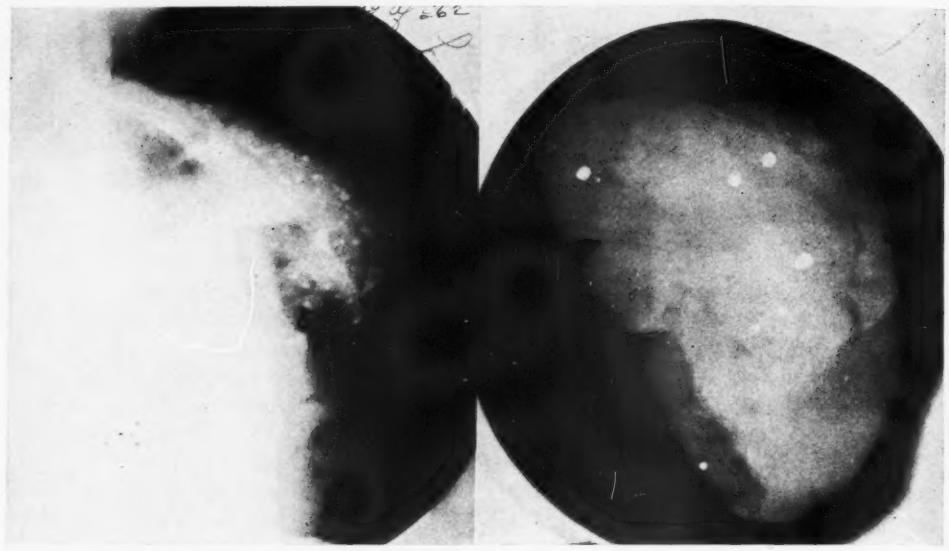

Fig. 1. Left upper quadrant, showing typical appearance of numerous calcified nodules in the spleen. These are characteristic of the appearance of phleboliths.
Fig. 2. Spleen at autopsy showing typical rounded calcified nodules which proved to be phleboliths.

Fig. 3. Microscopic section, after decalcification, from spleen shown in Figure 2. Note splenic pulp above, atrophying vein wall, fibrillar structure with some calcium, and dense granular center. The appearance is characteristic of an organized, calcified thrombus.

In the past three years we have observed 18 cases of miliary calcification in the spleen, discovered accidentally during the course of x-ray examinations of the chest and abdomen. Sixteen were from the University of Minnesota Hospitals, and two were studied through the courtesy of Dr. L. G. Ericksen and Dr. F. P. McNamara, of the Finley Hospital, Dubuque, Iowa. The cases are listed in Table I, in chronological order. Ten were males and six females. Thirteen were 40 years of age or older. Three cases (Nos. 3, 4, and 7) showed a quiescent adult type of pulmonary tuberculosis. Case 1, a girl 13 years of age, presented multiple calcified Ghon's tubercles in the right lung. Of these four, only one (No. 4) gave a clinical history of tuberculosis (urogenital). We have no histologic proof in any of these cases, but it is logical to admit the probability of the tuberculous nature of the splenic calcification.

Case 2, 28 years of age, had a normal chest roentgenogram, and the etiology of

the splenic calcifications here is doubtful. The patient's age favors tuberculosis, but the absence of lung pathology favors phleboliths. Cases 5 and 9 are also doubtful, but probably represent phleboliths.

All the remaining cases (Nos. 6, 8, and 10–18) gave no clinical history of tuberculosis. In four, films of the chest showed no pathology; six exhibited calcified Ghon's tubercles. Three came to autopsy (Cases 10, 12, and 16), including two which showed calcified primary tuberculous lesions in the lungs. Histologic study of all three showed the calcifications to be phleboliths. This intimates strongly that the mere presence of a Ghon's tubercle does not indicate the tuberculous nature of miliary splenic calcifications.

ROENTGEN FINDINGS

These lesions may be discovered in a routine film of either the chest or abdomen. They vary in number from a dozen to several hundred, and in size from one to eight millimeters, averaging four or five. They are dense, sharply outlined shadows, usually round, but varying in shape, depending on the angle the central ray forms with the long axis of the thrombosed vein. The center of the calcified areas may be denser than the periphery, but this is not constant. In this series we were unable to find any distinguishing characteristics between the phleboliths and the calcifications ascribed to tuberculosis. Figure 1 shows the typical appearance in the roentgenogram. Figure 2 is a film of the spleen made postmortem to show the character of shadows known to be phleboliths.

PATHOLOGIC FINDINGS

The lesions may be found under the capsule of the spleen and scattered anywhere throughout the parenchyma. They tend to follow the course of the larger veins in the trabeculæ, whereas tubercles are in the pulp itself. Microscopically (after decalcification) the phlebolith presents a granular center which is more densely calcified than the periphery. About this central core the structure becomes fibrillar and looser, with fewer granules of calcium. This layer merges with the atrophying vein wall and evidences of old organization of a thrombus can often still be made out. A section was made of a non-calcified nodule. This also presents a hyalinizing structure of capillaries and fibrous tissue indicative of organizing thrombus. Figure 3 shows the typical microscopic appearance, characteristic of phleboliths. It would appear, therefore, that most miliary calcifications of the spleen are phleboliths. If the patient presents evidence of tuberculosis of the lungs or elsewhere, then the splenic calcifications may be tuberculous in origin, particularly in children and young adults. The presence of calcified Ghon's tubercle only does not necessarily indicate that the lesions are tuberculous in nature, except in children. In adults the vast majority of cases can definitely be classed as phleboliths and probably should be so considered until proven to be tuberculous.

SUMMARY AND CONCLUSIONS

1. The literature on miliary calcification of the spleen is briefly reviewed.

2. Eighteen additional cases are presented.

3. Histologic studies of three cases are reported.

4. Most of the miliary calcifications of the spleen observed roentgenologically represent phleboliths rather than healed tubercles.

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RADIATION OF THE THYROID[1]

AN EXPERIMENTAL STUDY IN RADIOSENSITIVITY OF THE THYROID

By CLARENCE T. ECKERT, M.D., J. G. PROBSTEIN, M.D., F.A.C.S., *and* SIM GALINSON, M.D., *St. Louis, Mo.*

From the Surgical Department and Laboratory of the Jewish Hospital

THE term "radiosensitivity," as with all comparative expressions, is at times ambiguous and misleading. This is particularly the case when the term is used in describing newgrowths. Normal tissue, however, is much more constant and reliable in its reactions to radiation. With this in mind, normal thyroid has been classed as a very radioresistant tissue.

The low standing of normal thyroid in the scale of radiosensitivity is based upon the fact that relatively large amounts of radiation fail to alter the histology or physiology of the gland. This is an unusual and unexpected finding in a part with such a high epithelial content and extreme histologic mutability, factors which tend to increase radiosensitivity.

It was our purpose to further study the effects of radiation upon normal thyroid. In addition to the usual method of radiating the thyroid and examining the latter for microscopic changes, we also studied the effects of radiation of the thyroid with reference to the reaction of the gland to certain stimuli. We used two methods to stimulate thyroid activity: one was the removal of one and a half lobes of the thyroid which results in a later compensatory hypertrophy of the remaining half lobe; the second method was the intraperitoneal injection of the acid extract of the anterior pituitary which causes a marked thyroid hypertrophy and other changes which closely simulate exophthalmic goiter. By radiating the thyroids previous to subjecting them to the above methods of stimulation, we hoped to throw light upon the radiosensitivity of the thyroid cell from a somewhat different source.

[1] This study was aided by a grant from the David May Research Fund of the Jewish Hospital.

EXPERIMENTAL METHODS AND RESULTS

All of the animals used were young guinea pigs of both sexes, weighing from 200 to 400 grams, and all were on the same diet throughout the experiment. As a source of radiation we employed radium, using five 10-mg. needles and one 50-mg. capsule. All applications were made at a distance of 1 cm., for which we used a wood block. One-half mm. of lead was used for screening. In order to limit the radiation to the thyroid, the application was given through a lead fenestrum which was bent so as to fit closely around the thyroid area.

In order to more thoroughly observe the histologic changes caused by the experimental procedures, serial sections were made of all the thyroids, including the controls. To judge the amount of reaction to the radiation we observed for the usual destructive changes such as loss of staining quality, enlargement of nuclei, pyknosis, etc.

As an index of thyroid activity we considered the usual criteria such as:

1. Height and condition of epithelium.
2. Size and shape of acini.
3. Amount and condition of colloid.
4. Interacinar changes such as lymphocytic infiltration, colloid deposits, etc.

Ether anesthesia was used for all operative procedures and for destroying animals to obtain specimens.

Experiment I.—Radiation to the Normal Thyroid.—For this part of the work we used 40 animals and gave from 50 to 400 mg.-hr. of radiation to the thyroids. The latter were then removed, from 1 to 58 days after the applications.

All of the guinea pigs in this group behaved in the usual manner and showed normal gains in weight during the stated

period. They could not be distinguished from a smaller group of 28 animals which were not radiated and thus used for controls. On an average the thyroids of the radiated animals were grossly and microscopically indistinguishable from those of the controls. Sections of the radiated glands failed to reveal any histologic changes which could be attributed to radiation; neither destruction nor fibrosis was found in any of the radiated thyroids. Likewise the activity of the thyroids seemed to be unaffected by the radiation, as the epithelium remained a low cuboidal, the acini medium, the colloid firm, and no interacinar changes were evident.

Experiment II.—Compensatory Hypertrophy after Radiation.—The animals used in Experiment I were again used in this second study. In the 28 controls, or non-radiated animals, one and a half lobes of the thyroid were removed and the residual half lobe was permitted to remain for from 14 to 22 days before excision. Similarly, in 23 of the radiated animals in Experiment I, all of which had received from 100 to 150 mg.-hr. of radiation from 1 to 58 days before operation, one and a half lobes of the thyroid were removed, and the remaining half lobe was excised from 14 to 22 days later.

Of the controls, 20 of the 28, or 71.4 per cent, of the animals with thyroid residue showed signs of a compensatory hypertrophy, characterized by increase in the height of the epithelium from flat to columnar or cuboidal, smaller acini with occasional infoldings, definite depletion of colloid, and in some cases interacinar lymphocytic infiltrations. Only six of the 23 radiated animals, or 26.1 per cent, demonstrated these characteristics of a compensatory hypertrophy. None of the radiated animals showed any signs of histologic reaction to the radiation.

Experiment III.—Intraperitoneal Injection of the Acid Extract of the Anterior Pituitary after Radiation.—For this series we used 13 animals of larger size, weighing from 400 to 600 grams. Six were controls and seven were radiated. The latter were given 300 mg.-hr. of radium over the thyroids from six to ten days previous to the time of starting the injections. The acid extract of the anterior pituitary was then given intraperitoneally to the 13 animals, 0.5 c.c. the first day, and 1 c.c. daily for the next five days. All thyroids were removed on the seventh day.

During this experiment all of the guinea pigs lost from 30 to 90 grams in weight, the larger animals losing more than the smaller. There was no evidence of any relation between the weight loss and thyroid histology. The usual reactions to these injections such as increase in cardiac rate, extreme irritability, and exophthalmos, were noticed to be approximately as marked in the controls as in the radiated animals.

Grossly all of the thyroids appeared larger than normal but were not weighed. Microscopically all of the specimens showed hypertrophy and hyperplasia. However, the reaction was much more marked in the controls than in the radiated animals. For example, in all of the radiated thyroids there was much cuboidal epithelium, and in two cases areas of normal flat epithelial cells were found, whereas in the six controls the thyroid epithelium was entirely columnar except for scattered areas of cuboidal epithelium in three cases. Similarly, the acini in the controls were on the average much smaller than in the radiated animals, much less colloid was found in the controls, and epithelial invaginations were much more frequent than in the radiated animals. Areas of normal appearing thyroid were found in four of the radiated thyroids and in none of the controls.

In this experiment we again failed to find any histologic signs of destruction which could have been attributed to radiation.

DISCUSSION

The histologically demonstrable resistance of the normal thyroid to even very extensive radiation is a well established fact. For example, Bower and Clark (1) inserted 12.5 mg. radium needles directly into the thyroids of dogs, permitted the needles to remain from 2 to $13\frac{1}{2}$ hours,

and removed the glands for section in from seven to 210 days. They found, immediately surrounding the needle site, the usual area of destruction which began to organize and heal after the third week. However, no changes of parenchyma or blood vessels were observed outside the destroyed area. Their observation of the apparent resistance of the thyroid to the rays led them to make the interesting conjecture that "whether this resistance is due to the colloid contained in the thyroid, to the adult fixed character of the cells composing it, or to a deficiency in autolytic ferments, we are not prepared to state; but comparison of results with those obtained in other organs and tissues rich in enzymes and autolytic ferments would point toward the latter as a possible explanation."

Friedman and Blumgart (2) met this "resistance" in attempts to permanently lower the basal metabolic rate in cases of chronic heart disease by the administration of extensive x-ray treatments to the thyroid. The roentgen irradiation failed to produce any persistent lowering of the basal metabolic rate and, in the instances in which the thyroids were later removed, microscopic examinations of the gland showed normal thyroid.

Consequently it was not unexpected that the relatively moderate doses of radiation employed in this experiment should fail to produce histologic changes in the normal thyroid. No attempt was made in this work to explain why normal thyroid is so resistant to radiation (with reference to histologic changes). It is our opinion, however, that the tremendous blood circulation of the thyroid, calculated to be 500 c.c. per 100 gm. of thyroid per minute (3), tends to dissipate the effects of radiation.

We found no evidence, either grossly or microscopically, of stimulation in the thyroids which had been only radiated. The radiation seemingly did not cause any epithelial proliferation or "resorption of the products of secretion of the glands," *i.e.*, colloid, as found by Florentin and Watrin (4), after irradiation with x-ray using "two short radiations of the tracheal region with weak doses."

Compensatory hypertrophy of the thyroids in guinea pigs is a phenomenon subject to wide variations. However, our figure of 71.4 per cent in the controls compares favorably with that of Loeb (5), who found that 63.5 per cent of his animals showed hypertrophy during all of the months except June, July, August, and September. Our work was done from January to May, running the controls and the radiated animals simultaneously. Thus it would seem that with the finding of compensatory hypertrophy in only 26.1 per cent of the radiated thyroids, we have the right to conclude that the radiation definitely impaired the ability of the gland to hypertrophy. Walter, Anson, and Ivy (6) performed an experiment which seems to further substantiate this conclusion. By the use of x-ray they were able to definitely decrease, but not entirely prevent, the hyperplasia of the thyroid gland that occurs in opossums on a high protein (meat) diet.

The hypertrophy and hyperplasia as produced in the guinea pig thyroids by the intraperitoneal injection of the acid extract of the anterior pituitary, presents a picture of excessive thyroid activity, both clinically and microscopically. For more detailed information concerning this phenomenon, one can refer to the many excellent papers of Loeb and his co-workers. While none of the seven radiated animals in this group showed entirely normal histology following the injections, there was no doubt that in all of the six non-radiated controls thyroid activity was much more marked. Also the fact that sections of four of the radiated thyroids showed definite areas of normal appearing gland would indicate, again, that radiation definitely impairs the ability of the thyroid cell to reproduce.

An interesting observation was the failure of the radium to influence or prevent the exophthalmos produced by the intraperitoneal injections. Marine and Rosen (7) claim that at least two factors are nec-

essary for the production of exophthalmos: first, a relative or absolute deficient thyroid secretion, and second, an excess of thyrotropic factor. We can only assume that non-destructive doses of radiation, as applied previous to the administration of the thyrotropic anterior pituitary extract, are insufficient to influence, or possibly do not affect, the production of exophthalmos.

We feel that our work indicates that the radiosensitive portion of the thyroid gland is the parenchyma itself. More directly, we may infer that radiation decreases the reproductive power of the thyroid epithelial cell. Since nuclear activity causes cell division, the nucleus is the apparently radiosensitive portion of the thyroid cell. Thus we have shown that the degree of radiosensitivity is not necessarily indicated by variations in the amount of cell destruction. It is probably, as Von Wasserman (8) suggests, that the selective action of the radiation may merely destroy the proliferative power of the cell and leave it in a rather purely vegetative condition. Another observer, Prime (8), makes the interesting statement: "It is probable that the nucleus of the physically functionating cell is as much damaged as that of the inactive type but that as such cells expend their metabolic surplus in mechanical movements and not in increasing in size and dividing, as do the connective tissue and cancer cells, the effect of radium is not evident."

In considering the clinical application of this work, it is not our purpose to present radiation of the thyroid as a method in opposition to surgery. Most of the literature from either source is decidedly partial, and as Portmann (9) says, "usually arguments about the subject are based upon prejudices and simply amount to presentations of the objections to each procedure rather than the benefits." However, it seems that a method of treatment (radiation) which so definitely impairs the ability of the thyroid parenchyma to reproduce, should be of untold value in the therapy of hyperthyroid states. Even should the radiation fail to change the physiologic state enough to effect a cure, and surgery become necessary, it seems logical to assume that the decreased reproductive potentiality of the thyroid cell would lessen the possibility of recurrence. In fact, one observer, Quigley (10), states that he did not know of a case "that has been properly treated with radium radiation, even though the radium radiation has been unsuccessful in controlling the symptoms, that has recurred following a subsequent surgical operation. Apparently the radium radiation reduces the likelihood of recurrence or prevents it altogether."

CONCLUSIONS

1. Moderate radium irradiation—50–400 mg.-hr. at 0.5 c.c. distance with 0.5 mm. of lead for screening—will produce no histologic changes in thyroids of guinea pigs.

2. Such radiation in doses of from 100 to 300 mg.-hr. will definitely impair the ability of the thyroid parenchyma to reproduce as shown by compensatory hypertrophy and the reaction to the intraperitoneal injection of the acid extract of the anterior pituitary.

We wish to thank Dr. Samuel H. Gray for his many valuable suggestions throughout the progress of the experiment.

We also wish to thank Dr. Leo Loeb for the acid extract of the anterior pituitary used in this work.

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A BIOLOGIC TEST OF THE INVERSE SQUARE LAW AS APPLIED TO ROENTGEN RADIATION

By H. DABNEY KERR, M.D., *Iowa City, Iowa, and* TITUS C. EVANS, PH.D., *College Station, Texas*

From the Departments of Radiology and Zoology, State University of Iowa

THE authors have been interested in the employment of grasshopper eggs as a biologic test material for effects of roentgen radiation. The first paper dealt with the quantitative responses of this material to variations in amounts of radiation (3), the next report related to effects of developmental activity on biologic responses to radiation (4), and a third gave the biologic effects of radiation on the different stages of development (5). It has been generally accepted that the intensity of radiation falls off inversely as the square of the distance, and the measurement of the intensity by physical means is in close accord with this law. Yet the writers have been unable to find a paper dealing directly with a biologic test of this generalization. The experiments to be reported in the present paper were undertaken to determine whether or not the biologic effectiveness of the radiation on these organisms falls off inversely as the square of the distance.

MATERIAL AND METHOD

The biologic material employed was the egg of the grasshopper, *Melanoplus differentialis* (unless otherwise indicated). The reader is referred to the papers of Bodine (1 and 2), and Slifer (11) for the details of its development. Eggs were collected each day and immediately placed at the incubation temperature (25° C.). The age of the eggs was calculated by the number of days at the developmental temperatures, and samples were checked by dissection and observation under the binocular dissecting microscope.

The source of the radiation was a Coolidge, broad-focus, Universal tube, and was operated at 130 kv. and 5 ma. The intensity was measured by means of the commercial Victoreen dosimeter. In order to eliminate back-scatter, the organisms were placed on a cloth supported at a known distance under the target of the tube.

EXPERIMENTAL

The first experiments consisted of raying eggs with exposures of one minute at different distances. It was found that as the intensity at the shortest distance employed (30 cm.) was 200 roentgens per minute, the dosage rapidly fell to that which was below the level of sensitivity of the eggs. Biologic effects at distances of 10 to 30 cm. were consistent, however, and closely approached the curve of the inverse square law. With more extensive changes in intensity, the results were not consistent. It was, therefore, decided to use a higher dosage, which would make the maximum effect so great that marked changes in distance would not lower the dosage too greatly. Therefore, in other experiments of the same nature the exposure time was increased to one and one-half minutes which made the initial dose 300 roentgens. The number of eggs affected at the shortest distance (30 cm.) was almost 100 per cent and the effect did not approach zero until the maximum distance (80 cm.) was reached. It is thus indicated that one factor in such experiments is the range of dosages involved.

Figure 1 shows the results of several experiments in which the exposure time was kept constant and the distance varied. The intensity and dosage, measured by the dosimeter, follow the theoretical curve of the inverse square law, and are shown by the curve labelled "intensity and dosage." Curve No. 1 represents the average reaction in seven experiments using eggs from one to two days of age. There were 11

distances tested, and 50 eggs were used for each single experiment. The eggs were examined at the time of diapause (21 days at 25° C.) when the embryos were developmentally inactive. If an embryo exhibited any injury or defect, no matter how small, it was considered as affected and the "percentage of effect" as shown on the ordinates is an indication of the number of eggs affected but does not represent the extent of injury per individual. In Curve 1 this is not a factor, as the one-day eggs are either totally or not at all affected. It will be noted that the biologic curve approximates or parallels the theoretical one from 40 cm. to about 65 cm., but at the extremes the curves differ. In other words, it indicates that if the change in distance is small, the change in biologic effect is relatively less, and if the change in distance is extreme then the loss in biologic effect is greater than predicted by the inverse square law.

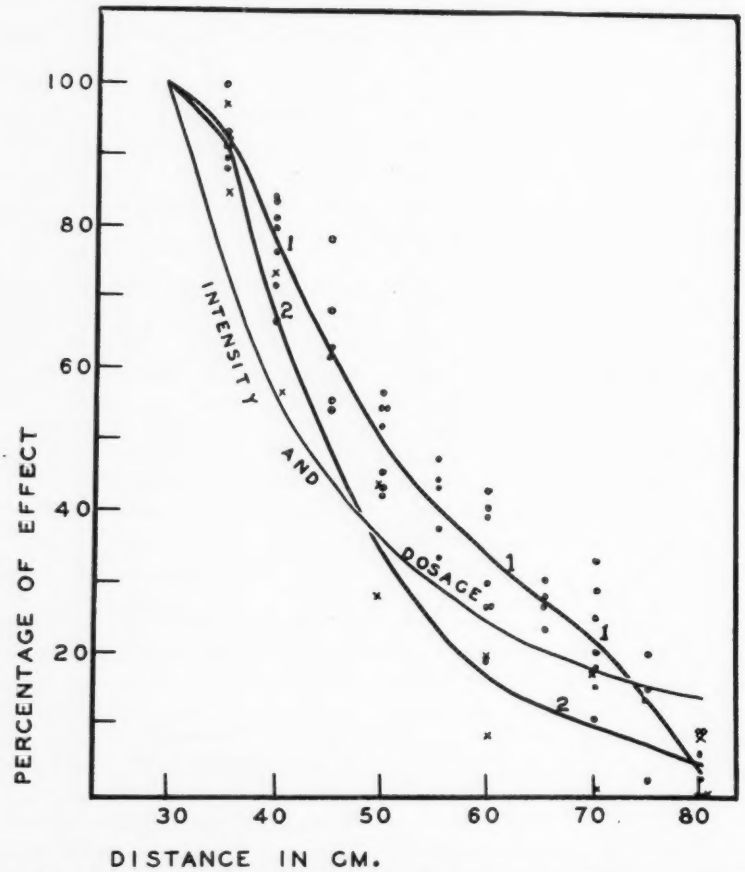

Fig. 1. A graph showing the effects on the intensity and on the percentage of biologic effect of increasing the distance. The abscissas indicate the distance in cm., and the ordinates show the percentage of biologic effect. The number of eggs injured at 30 cm. has been considered as 100 per cent. The intensity at 30 cm. was 200 roentgens per minute. The time of exposure was one and one-half minutes, making the dosage 300 r at 30 cm. Curve 1 drawn through the circles gives the results of irradiating one-to-two-day-old eggs. The results of similar experiments on five-to-six-day eggs are shown by Curve 2, which is drawn through the crosses.

Curve No. 2 represents the average

effect of increased distance on the biologic response of five-to-six-day eggs. The variation of the biologic reaction from the theoretical is still more pronounced. This difference indicates that the character of the biologic test material is a factor in determining the effect of varying the distance. All of the cells of the one-day eggs are totipotent, and eggs vary widely in sensitivity. This might account for the variation between Curves 1 and 2. The eggs of Curve 2 are more differentiated and have to some extent lost the power of regulation. The range of effective dosages is more restricted, and as the dosage is decreased by increasing the distance the effect falls off very rapidly.

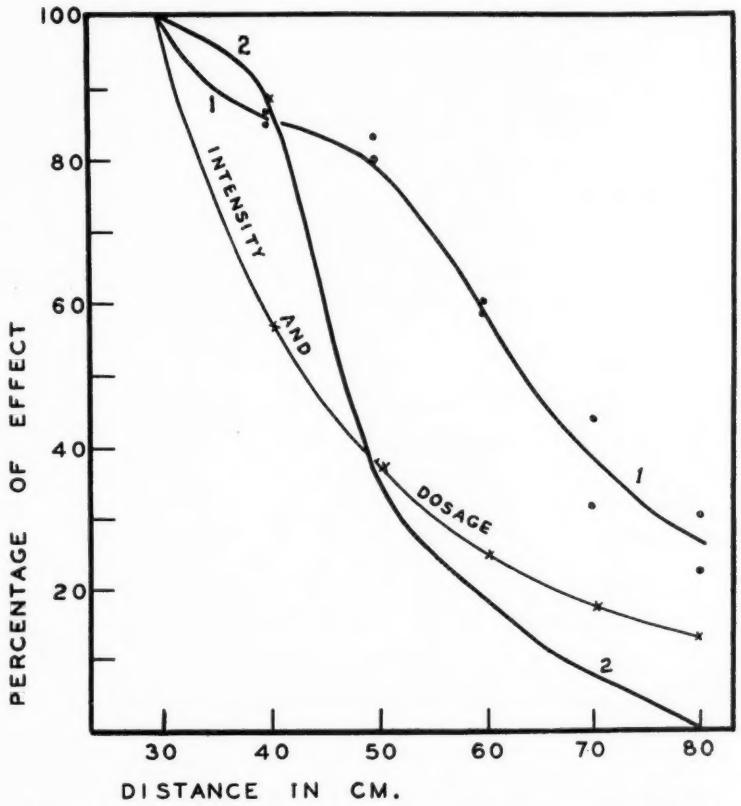

Fig. 2. A graph showing the results of experiments similar to those of Figure 1, except that eggs of *M. bivitattus* were employed. Curve 1 is for one-day eggs, and Curve 2 is for eggs six days of age.

The effect of the character of the biologic material on the type of response to increased distance is even more marked in different species. Experiments similar to the above were run with eggs of a closely related species, *M. bivitattus*. The graphs in Figure 2 show the results of these experiments. Curve 1 is of one-day eggs, and the line connecting the highest with the lowest percentage of effect is more nearly straight than that of the actual dosage. This is due, no doubt, to the wide range of effective dosages. Curve 2 is of six-day eggs and the sigmoid curve is indicative of a biologic population which is homogeneous in radiosensitivity. In other words, with the older, more differentiated embryos it requires a

higher dosage before any eggs are affected and then, as the dosage is slightly increased, the number affected quickly reaches the maximum. These experiments indicate that the inverse square law seems in general to hold where the population is fairly homogeneous, but that the biologic effect does not fall off so rapidly as does the dosage with small increases in distance, and that with extreme changes in distance the corresponding change in biologic effect is much greater. The slope of the biologic curve varies with the susceptibility and homogeneity of the population.

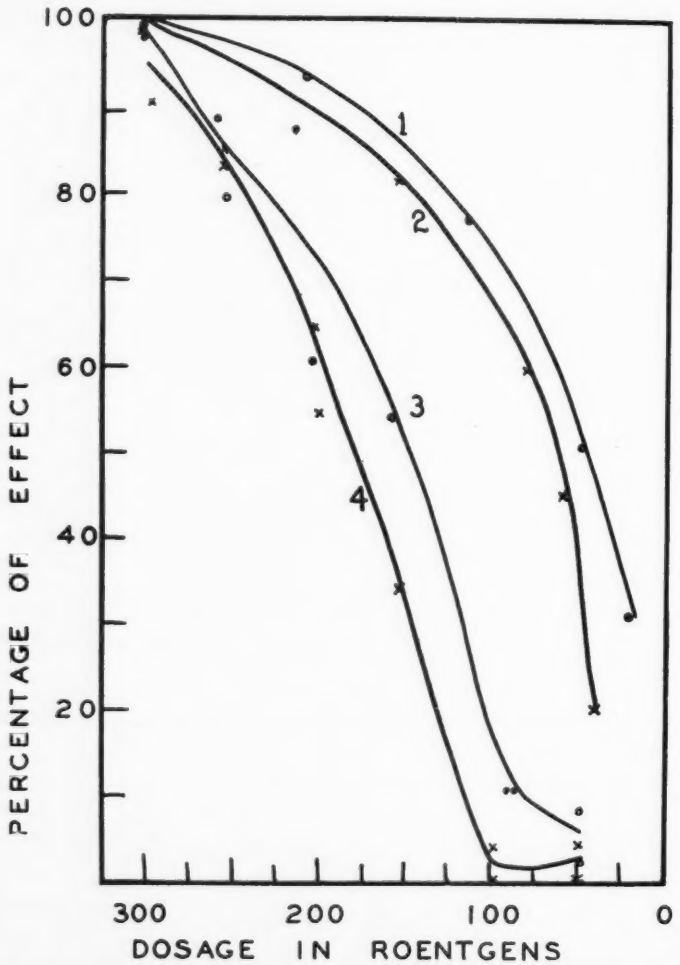

Fig. 3. Graphic presentation of experiments in which the dosage was decreased by different means. Curve 1 indicates the response of one-day-old *M. bivitattus* eggs when the dosage was decreased by decreasing the exposure time. Curve 2 is for similar eggs, but the dosage was decreased by increasing the distance. Curve 3 is for *M. bivitattus* eggs six days of age, and the dosage was decreased by shortening the exposure time. Curve 4 is for similar eggs, and the dosage was decreased by increasing the distance.

The next experiments were designed to study some of the factors involved in the explanation of the variation from that of the inverse square law. One of the first

things to be considered was the sensitivity of the biologic response. This was done by comparing the percentage of effect when 30 cm. (Curve 3) than at 70 or 80 cm. (Curve 4) in experiments on six-day eggs. This is an indication that susceptibility to

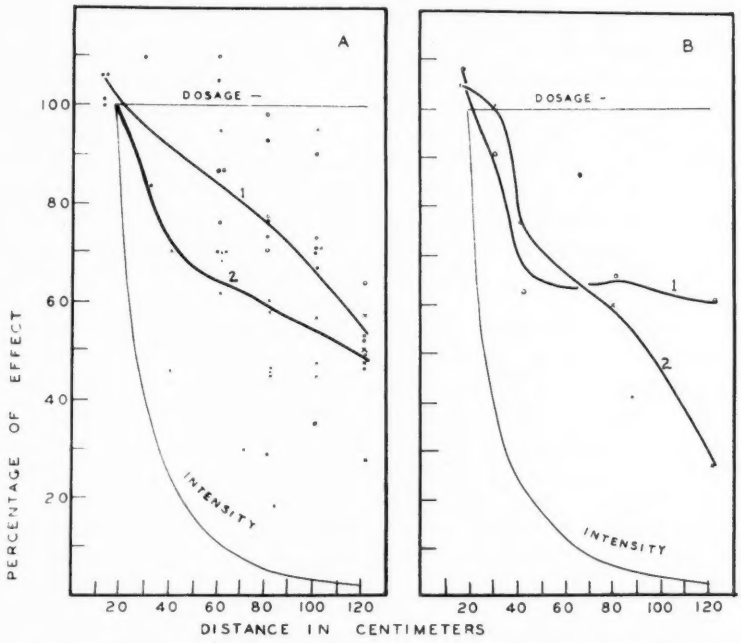

Fig. 4. Two graphs showing the effects of changing the intensity of irradiation by increasing the distance. Graph A is for experiments with *M. differentialis*. The dosage was kept constant by increasing the exposure time while the distance was increased. Curve 1 is for one-to-two-day eggs; Curve 2 is for five-to-six-day eggs. Graph B is of similar experiments in which *M. bivitattus* eggs were used. Curve 1 is for one-day eggs, and Curve 2 is for six-day eggs.

the dosage was decreased in two different ways. The first method was to decrease the exposure time, and the second was to increase the distance. The initial time was kept constant in both cases, and the effects of similar dosages were compared. Figure 3 is a graphic representation of the results of such experiments on *M. bivitattus* eggs. Curve 1 is for one-day eggs in which the dosage was decreased by shortening the exposure time. Curve 2 is for similar eggs in which the dosage was decreased by proper increases of distance. It will be noted that the decrease in effect due to increasing the distance was greater than that due to decreasing the exposure time. A certain dosage was also more effective at total dosage is not *per se* the only factor in the determination of the biologic effect.

The remaining factor to be accounted for is that of intensity, and the foregoing experiments have indicated the strong possibility of its being important. The change in intensity in the preceding experiments was not very large, so it was decided to increase this variation in order to magnify the appearance of the intensity factor. The greatest intensity employed was 575 r/m (17 cm.), and the lowest was 11 r/m (120 cm.). Figure 4 shows the results of the experiments on intensity. In these experiments the total dosage was kept constant and only the intensity and exposure time varied. Graph A of Figure 4 gives the

results of the experiments with *M. differentialis* eggs, and Graph B is for *M. bivitattus*. Curve 1 in each case is for one-day eggs, and Curve 2 is for six-day eggs. It is evident in all four types of experiments that intensity is a factor, and that the biologic effect changes as the intensity is decreased, even though the exposure time be increased enough to make the total dosage the same.

It is also evident that there is considerable variation in actual values, but there is a tendency which indicates that with a larger number of experiments the decrease in effect due to decreased intensity would approach a straight line, or establish a constant.

As soon as it became evident that intensity is a factor, the question arose as to whether or not intensity is a factor *per se* or whether the decrease in effect is due to recovery during the prolonged exposure. Nine experiments of 50 eggs to each lot have been performed in an attempt to answer this question in a preliminary manner, and the results are tabulated below:

High intensity, short exposure, averaged 87 per cent affected at 200 r.
Low intensity, long exposure (22 min.), 57 per cent affected at 200 r.
High intensity, long interval (22 min.) between the two halves of the irradiation, 76 per cent affected at 200 r.

Thus it is evident that possibly some of the effect is due to recovery, and part is due to the low intensity as such.

DISCUSSION

The first factor which the writers found to alter the biologic curve from that of the theoretical is the character of the test material. This factor has already been recognized by Henshaw and Francis (7) in their investigation of the biologic effects of roentgen irradiation at different depths of a paraffin phantom. The above authors found that not only were the biologic measurements different from the ionization measurements but the biologic measurements differed among themselves at different depths.

The other factor which has been noted in the present study is intensity. Roesler and Henshaw (10) were able to demonstrate a biologic difference in the effect of radiation delivered at 13 roentgens per minute, as compared with 234 r/m. *Drosophila* was the test material used. Packard (9) had previously found intensity not to be a factor, but his intensities varied only in the ratio of 1:4, whereas Roesler and Henshaw used a ratio of 1:18. Koidsumi (8) found in *Dacus* that intensity was not a factor and that the Bunsen Roscoe law held, but he also used a ratio of only 1:4. In the present experiments on grasshopper eggs a definite decrease in biologic effect has been found as the intensity is lowered. When the intensity was decreased more than 50 per cent, loss in biologic effect has been recorded. The preliminary experiments on divided dosages indicate that recovery will not account for all of the apparent effects of decreasing intensity. This finding has a substantiation in a more fundamental reaction such as noted in experiments on effects of radiations on chemical reactions by Fricke (6), who found intensity to be a factor *per se* in the decomposition of hydrogen peroxide.

CONCLUSIONS

Developing eggs of the grasshopper have been irradiated at different distances for a constant time exposure, and in some experiments the effect appears to fall off according to the inverse square law. The following factors have been found to modify the biologic curve from that of the theoretical:

(1) The effectiveness of the dosage at the shortest distance.
(2) Developmental stage of biologic test material, and the way in which the material responds to changes in amount of radiation.
(3) Intensity *per se*.
(4) Low intensities where time allows some recovery or enough development to make the organisms more resistant.

The authors wish to express their ap-

preciation to Prof. J. H. Bodine for his counsel and suggestions.

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SOME LAWSUITS I HAVE MET AND SOME OF THE LESSONS TO BE LEARNED FROM THEM[1]

(Second Series, Second Installment)

By I. S. TROSTLER, M.D., F.A.C.R., F.A.C.P., *Chicago*

A DISLOCATED SHOULDER AND WHAT CAME OF IT

TO the writer one of the most damnable attempts to throw the blame for malpractice upon an innocent man came up not long ago. The particulars are as follows:

A big "roughneck" in a midwestern city sustained a dislocation of the humeral head. He went to a competent, highly respected physician and surgeon, who, after having roentgen examination made, reduced the dislocation and had another roentgenogram made. A few days later the patient reappeared with a recurrence of the dislocation which was again reduced, and another roentgenogram made.

Several days later this patient appeared in a large city, where under an anesthetic in a hospital, a "big-town Doctor" placed his foot in the patient's axilla and tried (but failed) to reduce the dislocation. This Doctor testified that he pulled until he heard "something pop."

Within a few days, the patient was subjected to an open operation in another hospital in the city. After the lapse of considerable time, during which the shoulder was slow in healing, the city doctors informed the patient that, because of improper treatment by his home-town physician, the shoulder would not heal for a long time—if ever.

After all this, the patient brought a malpractice suit for $50,000 damages against the first physician. At the first trial, one of the men who operated on the shoulder testified (making a 500-mile trip for that purpose), and two of the others testified by affidavit. Fortunately, their testimony did not agree as to the findings, etc., nor as to who did the operating. With that and the real doubt as to the guilt of the good doctor, the jury was unable to agree, and no verdict was brought in.

After the lapse of about a year and a half, the case was set for retrial, and during the preparation of the defendant's case, my name was mentioned as being one who possibly might help. After a brief correspondence during which I learned much about the case, the attorney for the defendant brought the films in the case to my office in Chicago, and after studying them and listening to the entire story, including the testimony of the city physicians, I made the following analysis of the situation: The defendant had twice successfully and correctly reduced the dislocation and had films to prove same. The first city physician who had put his foot in the plaintiff's axilla and "pulled until something popped," had fractured the humeral tuberosity, and the surgeons who performed the open operation had injured the rim of the glenoid fossa with the "Lane skid," which they testified as having used to get the head of the humerus into the fossa. And, what was apparently more to the point, these men, realizing what they had done, felt it incumbent to hide their own culpability, and to throw the blame upon the defendant in the suit. This was all brought out by reading between the lines of the affidavits and the testimony of the city physicians and was *verified by the roentgenograms*, of which there were plenty.

In the meantime, the two-year limitation of the statute in the city had lapsed, so that at the time of the second trial the city physicians had no more fear of suit against them. Consequently, *they* lost in-

[1] The Editor desires to state that much of the matter herein, because quotations of court proceedings, has to be printed in form as received, without normal punctuation or phrasing.

terest in the case, and none of them testified at the second trial. However, their testimony of the previous trial was admitted at this (second) trial. It was arranged that I was to attend the second trial, and when it came up I appeared as an expert witness. I testified that the films made after the first two dislocations showed the head of the humerus to be in its proper and natural place and that no fractures were present; that the films made in the city showed dislocation of the head of the humerus and fractures of the greater tuberosity of the humerus and of the rim of the glenoid fossa. Much of my testimony was given while examining the films in a stereoscope—which I had requested be brought into the courtroom—and explaining the stereoroentgenograms to each of the twelve jurors individually, as they viewed them in the stereoscope. This consumed much time, but it was time well spent.

It was immediately evident that my testimony created intense interest in the minds of those present. The jurymen sat on the edges of their chairs much of the time, and interestedly came, one by one, to the witness box to have the films explained to them. During the recesses the court reporter, the judge, the plaintiff and his wife, as well as one of the plaintiff's attorneys, asked me to show and explain the films in the stereoscope. *I explained some of the films eighteen times.*

I had been warned that the principal attorney for the plaintiff was decidedly tough and inclined to grill opposing witnesses and naturally expected to receive rather severe treatment from him, but in this I was pleasantly disappointed. After a few sallies, during which he discovered that apparently he would not get very far with the old-timer, he merely tried to belittle the effect of my testimony by repeatedly stressing that I had appeared many times as a witness and that I expected to be paid for my services. In reply to a question as to whether I expected to be paid, I replied, "Certainly, I expect to be paid, just the same as you expect to be paid for coming here and trying this case." This slowed his curves for a bit, and he subsequently lost control of the ball—in baseball parlance.

The jury brought in a verdict for the defendant physician, and when a new trial was later asked for, the judge refused it. The time to take an appeal to the State Supreme Court had expired. The case may still be taken up on a writ of error, but this is not at all likely to be done.

This was one of my most gratifying appearances as a witness, mainly because it helped in the vindication of a fine, high type, ethical gentleman and proved that right will prevail, at least once in a while.

EXHIBITION OF AMPUTATION STUMP

Several years ago I received from a colleague in a distant State a letter which read as follows:

"I am vitally interested in a personal injury case and would like some of your valuable advice. A younger brother of mine had a serious accident about a year ago, the end-result of which was the loss of his left foot above the ankle. On account of his refusal to accept a ridiculously small sum in settlement he sued the building contractor who was responsible for the accident which caused the injury.

"At the trial my brother's attorney directed him to show his amputation stump to the jury, but the attorney for the contractor objected to this, and the judge before whom the case was tried sustained the objection. That same afternoon, my brother tried to introduce a photograph of his stump, but this was also objected to and ruled out. The jury brought in a verdict for my brother but fixed the damages at so small an amount that a new trial was immediately asked for. This was denied. Now my brother's attorney has appealed the case to our Court of Appeals, and knowing that you have had a world of experience, I am asking you to give me—for my brother—such comment and advice as you can."

After a few days I wrote as follows: "Replying to your letter relative to your brother's case, will say that I have had no

experience in that line, but after interviewing two friends in the legal profession who owed me something of that sort, I was informed that the rule regarding the display or exhibition of injured limbs or members to the jury in personal injury cases is considered to be founded upon good reason and is consequently generally permitted. This is because exhibition of amputation stumps and of the amputated parts are the best means of showing the actual character and extent of the maiming of the individual involved. Of course, if the exhibition would necessitate any indecent exposure or exposure of the private or sexual parts, it would not be permissible. I was informed by both the attorneys questioned that it is preferable and considered best for justice between the litigants that the court order an inspection and it is within the discretion of the court to either allow or to order such an exhibition or inspection. Both of my informants asserted that any objection on the ground that such an exhibition had a marked tendency to excite and/or elicit the sympathies of the jury is not tenable.

"They said this because they thought that that must have been the cause of the objection raised by the contractor's attorney and sustained by the judge. The exhibition of a stump in cases in which an amputation has been done is entirely different from allowing a lamed person to limp or display how badly crippled he is before the jury, because it is so evident that a limp or lameness may be and often is assumed, added to, or exaggerated.

"In Willis *vs.* City of Browning, 161 Mo. App. R., 461; 143 S.W.R. 516, it was held proper for the plaintiff to exhibit her injured ankle to the jury, but that it was error to show how she could walk upon the foot.

"Likewise, in Newport News and M.V. Ry. Co. *vs.* Carrol, 31 S.W.R. 132, a Kentucky case, and more recently in Ford *vs.* Providence Coal Co., 124 Ky. R., 99 S.W. R. 609, the exhibition of injured limbs was ruled to be proper. In fact, the decision in the latter case specifically states that such exhibition is the best obtainable evidence of the extent and character of the injury and results thereof.

"Again, in an Appellate Court case in Illinois, Johnson *vs.* Wasson Coal Company, 173 Ill. App. R. 414, the plaintiff exhibited his injured ankle to the jury but was not permitted to show how much or little motion he had in the ankle joint.

"I believe that numerous other cases can be found, but doubt if more will be necessary. I am sure that your brother's attorney will be able to secure a reversal by your Court of Appeals and a rehearing on the points claimed," etc.

The Court of Appeals held that the refusal to allow the exhibition of plaintiff's amputation stump was error and remanded the case for a new trial, but before the case came up again the defendants settled by payment of an amount satisfactory to the plaintiff.

A HUNDRED THOUSAND DOLLAR DAMAGE SUIT

Not many radiologists rate high enough in Bradstreet's or Dun's commercial agencies to warrant even a suspicion that they might be sued for a $100,000. In fact, I know of but one who belongs to that group; therefore, the following tale.

In the Spring of 1929 I was visited by a well-known radiologist in search of advice relative to a malpractice suit in which that amount was being asked as damages, and in which he was the defendant. X-ray treatment had been administered to relieve a pruritus ani in a man prominent in public life. The immediate results were apparently good as the pruritus was promptly relieved. The trouble recurred about one year later, and four more applications of x-rays were administered, followed by a remission of the itching.

About one and one-half years later, this patient (plaintiff) alleged that he developed a dermatitis around the anus in the treated area, which became so bad that he had to be operated on and treated surgically for relief. For his suffering, injury, etc., he brought suit against the physician for the aforementioned amount.

The plaintiff was active in his State and in national politics and had made trips to different portions of the eastern United States. As he had admitted that he had had x-ray treatment elsewhere, it was thought likely that this treatment had been received in some of the places in which he had visited during these peregrinations. So that we might locate where the plaintiff did receive these treatments, it became my duty to write to over forty roentgenologists who seemed to be the most likely ones from whom this man might have received treatment; but no record could be found of his having any treatment, except the application of mercurochrome by a New York hotel physician, and of the recommendation and probable use of orthoform, by a well-known Chicago neurologist.

In the meantime—in order to as nearly as possible plan a defense—the writer wrote to two well-known roentgenologists, giving them the particulars of an hypothetical case, with the idea of arranging for them to appear as expert witnesses. This letter was as follows:

"I want to discuss an hypothetical case with you, and get your replies to an hypothetical question relative thereto.

"Given a patient, a man of 40 to 45 years, large, heavy (but you do not need to know that he is a blond), treated for pruritus ani as follows:

"Feb. 27, 1924—30 minutes, 4 ma., 20 in. F.S.D., 0.75 mm. Cu and 1 mm. Al filters, 180 kv.p.

"Same day—15 minutes, 4 ma., 12 in. F.S.D., 0.25 mm. Cu, and 1 mm. Al filters, 130 kv.p.

"Mar. 4, 1924—identically the same dosage as on Feb. 27.

"Patient was markedly relieved.

"Apr. 4, 1925—30 minutes, 4 ma., 20 in. F.S.D., 0.75 mm. Cu, and 1 mm. Al filters, 180 kv.p.

"Apr. 8, 1925—20 minutes, 4 ma., 12 in. F.S.D., 0.25 mm. Cu and 1 mm. Al filters, 130 kv.p.

"Apr. 14, 1925—10 minutes, same F.S.D., filters, and voltage.

"Apr. 26, 1925—25 minutes, all other elements of dosage the same as last two.

"This was followed by complete relief from the itching.

"The above figures are what you are to consider. Now then, is the above described dosage excessive? Is it within the limits of safety? Would you hesitate to apply that amount of radiation under those circumstances?

"Let your replies to the above questions be based upon the facts that the apparatus used by the man giving the above described treatments had been charted by Dr. Albert Bachem, and later by Dr. Arthur Erskine, as delivering a full dose with the 180 kv. p. voltage as above described in three hours.

"Incidentally, it might be of interest to suppose that one and one-half years after the last named date, this patient showed what appeared to be a third degree roentgen dermatitis around the anal opening. In the advent of this, would you not think it altogether likely that the patient had had some x-ray treatment *after the dates mentioned above?* And if the patient admitted to the physician now treating him for the dermatitis that he had had treatment elsewhere, but was still suing the original man for $100,000 damages, would you be willing to testify in the case, in defense of the doctor?

"Understand me, all this is regarding an hypothetical case and does not in any way refer to any particular individual, time, place, or thing, and is under no circumstances ever to be connected with any case or suit that you might ever hear of in the future or have heard of in the past."

Within a few days, one of the men to whom the foregoing was addressed replied as follows: ". . . In answer to your question, 'Is the above dosage excessive?' will say, (*a*) On a basis of an erythema reaction, I would state that the two applications administered February 27, I would conservatively estimate as being less than half the ordinary erythema dose, and this is likewise true of the two applications administered on March 4, at, respectively, 180 and 130 kv.p. This would suggest that the total treatments administered April 4, 8, 14, and 26, 1925, appear to be less than the equivalent of one and one-half erythemas if administered at one time; but since these

four applications were administered over a period of more than three weeks, careful calculation might estimate that the total skin effect would not show an erythematous reaction, provided, of course, all of the factors mentioned as to the three hours' time required to produce an erythema with the 180 kv.p is reasonably correct.

"I take into consideration the fact that the two series of treatments were administered one year apart, with special reference to the last mentioned dosage.

"(*b*) It is reasonable to presume that the above treatments would not produce a third degree dermatitis one and one-half years after their administration. This is especially true in view of the fact that there was no evidence of a marked reaction following the initial treatments in three, six, or eight weeks. It does not seem reasonable that medication following x-ray treatments could produce such a change in one and one-half years, but it is most acceptable to presume that additional radiation therapy had been applied. Employing soft or even penetrating radiation therapy, it might produce in part, at least, the third degree roentgen dermatitis mentioned.

"(*c*) The question of whether this type of treatment of high voltage for pruritus is preferable might be open to argument.

"However, the facts in this case do not indicate that even the dosage administered in 1924 and 1925 could produce such a delayed reaction in the location mentioned. We do occasionally see delayed fat necrosis. Personally, I have never observed the latter in any of my cases. Perhaps others have, after the patients have left my service.

"(*d*) Most assuredly I would be willing to testify in this case in defense of the Doctor even without a further careful check-up, since I realize that a third degree dermatitis could hardly follow the above treatment, even though a more careful analysis of the dosage may show that my figures are far too conservative.

"I would like to check this over more carefully. Whether or not the patient had subsequent x-ray treatment would not influence me in being unwilling to do my bit. Of course, if this is the case, it does make the defense a much simpler one. I have only a few days left at my own disposal and therefore hurriedly send you the above very superficial analysis. As soon as I return, I will go over these figures more thoroughly, and if I find any change in my deductions, will let you know."

A short time later, the other man wrote: "I have finally got measurements enough made to answer your hypothetical question. The enclosure gives the actual data. The doses are pretty high and the case should probably be settled. The last treatment was the wagonload of straws.

"If the case has to be fought, I would, of course, be willing to testify, and I have no doubt that further measurements (under office, instead of laboratory, conditions) would show the dosage to be considerably less."

The enclosure mentioned above quoted the technic given in my letter to him and the following, "Assuming the correctness of the data given and further assuming the size of the field treated to be 10 × 10 cm., and the tube to be of at least the average efficiency, actual measurement shows that the skin would receive, including backscatter, 6.5 r/minute with the 180 kv. technic and 17.5 r/minute with the 130 kv. technic.

The doses in r-units would, therefore, be as follows:

2/27/24	30 × 6.5	equals	195 r
2/27/24	15 × 17.5	"	262.5 r
3/ 4/24	30 × 6.5	"	195 r
3/ 4/24	15 × 17.5	"	262.5 r
Total			915 r
4/ 4/25	30 × 6.5	equals	195 r
4/ 8/25	30 × 17.5	"	350 r
4/14/25	20 × 17.5	"	175 r
4/26/25	25 × 17.5	"	437.5 r
Total			1157.5 r

"Conclusions: The 1924 dosage is certainly safe even if applied at one sitting. The 1925 dose is around the upper limit of safety (if one disregards the Pfahler curve).

If we admit the accuracy of the Pfahler curve (which after all is theoretical), the 1925 dosage need not be considered as a single dose and would be within the limit of safety. The judgement shown in giving 437.5 r at the end of the series is questionable."

In the meantime I had received the preliminary affidavits of both parties to the suit and wrote the attorney for one of the insurance companies—of the defendant—as follows:

"*In re* — *vs.* — No. 08487. After reviewing the affidavits of the principal parties to the above captioned case, and what was told me by the defendant, and what I can learn from other sources, I will give you my reaction and ruminations regarding same.

"While it is possibly immaterial, defendant told me that he had never presented a bill, nor received any payment for the treatments involved in this case.

"The application of mercurochrome by Dr. M. in the C. Hotel, in New York City after the hunting trip, as per plaintiff's statement, is bad treatment if an x-ray dermatitis (so-called x-ray burn) is present.

"The mixing up and attempt at implicating the tonsil operation at the P. Hospital in Chicago, and the hemorrhoid operation in M., O., is only an effort to throw the blame for these upon the defendant. These operations, and the cause for their being done, are separate and distinct entities, as much so as if he (plaintiff) had acquired a fracture and had to have an operation to cure that. They bear absolutely no relation to the pruritus. Pruritus frequently accompanies hemorrhoids or it (pruritus) may occur as an independent and distinct condition, requiring separate and distinct treatment. Also, the sciatica is a separate and distinct entity, probably depending in a measure upon the diseased tonsils, but having absolutely nothing to do with the pruritis or the x-ray treatment, *except possibly to show a deranged general nervous system.*

"Orthoform, as recommended by Dr. S. (who is one of Chicago's leading neurologists), is bad for roentgen dermatites—so-called x-ray burns. The dermatitis mentioned as occurring after the use of orthoform could not by any stretch of imagination have anything to do with the x-ray treatments or the roentgen dermatitis. That was probably the direct result of the application of the orthoform, and here again indicating *an unusual skin,* which may be used in defense of the presence of roentgen dermatitis.

"In defendant's deposition, the dates are not the same he gave to me while reading from what he said was his original record, nor are the figures of the voltage used the same as he gave to me. He gave 200 kilovolts (which means 200,000 volts) in the affidavit, but to me he gave 180 kilovolts and his record so read. Also, in his original record (as read to me by him in my office), the secondary treatment was 130 kilovolts (130,000 volts) while in the affidavit it was 150 kilovolts. For your information I will give you what his record stated (as read to me by defendant), and from which I have had to figure and ask the opinions of others:

"Feb. 27, 1924—30 minutes, 4 milliamperes, 180 kilovolts, 20 inches, 0.75 copper, 1 Al.
"Same day—15 minutes, 4 milliamperes, 130 kilovolts, 12 inches, 0.25 copper, 1 Al.
"March 4, 1924—identically the same doses, with relief from the itching.
"Apr. 2, 1925—30 minutes, 4 milliamperes, 180 kilovolts, 20 inches, 0.75 copper, 1 mm. Al.
"Apr. 8, 1925—20 minutes, 4 milliamperes, 130 kilovolts, 12 inches, 0.25 copper, 1 Al.
"Apr. 14, 1925—10 minutes, 4 milliamperes, 130 kilovolts, 12 inches, 0.25 copper, 1 Al.
"Apr. 26, 1925—25 minutes, 4 milliamperes, 130 kilovolts, 12 inches, 0.25 copper, 1 Al."

"Aside from the discrepancies between what Dr. T. showed me as his figures and the affidavit, in which he admits having given considerably larger doses and the admission to the plaintiff that he had burned him, there is little for me to discuss or comment upon at this time.

"It is not generally considered to be good practice to use as high a voltage as 200 kv. or even 180 kv. in the treatment of pruritus, and I very much doubt if you will be

able to find any roentgenologist of standing who will admit that he considers it good practice. However, the amount of x-rays applied to the plaintiff, at the times and under the circumstances and conditions given to me by Dr. T., from his original record, is not in my opinion and in the opinions of Dr. B. of St. L., and Dr. Y., of C., R., sufficient to produce the effect that plaintiff apparently has or had.

"Of course, if it is possible to find that plaintiff had x-ray treatments elsewhere, that will help the case enormously. Or if, as Dr. T. told me, the plaintiff told Dr. F. (who operated upon him) that he had had some x-ray treatments elsewere, and that evidence can be used, and not barred as privileged, that may and doubtlessly will help a lot. To me the fact that defendant gave me figures from his original record, and in his affidavit gave figures indicating that he gave *more* x-rays, is inexplicable. If he did one thing, *he did that*, and because he gave two different sets of figures, he weakened his case, *certainly to me*. Knowing him, as I do, to be decidedly more than usually precise and accurate in matters of this sort, I cannot help be just a bit vexed with him.

"As regards the use of the ultra-violet light, following after and upon a roentgen dermatitis, the medical profession is not at all agreed. Up to about two years ago, it was believed that it was good practice, by some pretty well informed men. Sampson advocated it in 1922 and stressed it in his book, which was published in 1924, and Greer, Swanberg, and Rulison were pretty strong advocates of the use of the ultra-violet light under these conditions. Personally, I never put any stock in it, and later my contention was borne out by actual experiments and proven, by such high class investigators as MacKee, Pfahler, and others. Tests made by these men were reported to make the skin more sensitive, by applying the ultra-violet light.

"Judging from the testimony given by the plaintiff, in his affidavit, it is apparent that he did have a mild x-ray dermatitis, and it is on the basis of this and the use of the 200 kilovolt technic, that Dr. B., of this city, was going to give the plaintiff an affidavit that the technic used by the defendant was not good practice. However, after a short talk with me, the Doctor decided not to give defendant any sort of testimony. Evidently they (defendant's attorys) are here trying to secure testimony that the technic was bad. Of course if I hear about it in time, I can help in that regard.

"I advised Dr. T. to get in touch with attorney D., of I. C., who is, in my opinion, one of the best men I know to defend a case of this sort. I also advised him to secure a number of high class expert witnesses and suggested the names of five well known men to him, besides the names of Mssrs. Bachem and Darnell as physicists.

"I believe that I told you that I have letters from the two men replying to my hypothetical questions relative to a parallel case to this, in which they both give as their opinions that the dosage as given by Dr. T. (to me) would not under normal conditions produce a 'burn,' and that they were ready to so testify, but I do not know what they will say regarding the dosage as given by defendant in his affidavit.

"Of course, much depends upon what can be developed from the information that can be secured from the G. Hospital in W. Defendant has written to a man there to look up that material.

"Also, most vigorous efforts must be made to exclude the doctrine of *res ipsa loquitur* being applied in connection with this case. I do not know how the courts in that State hold in that regard. It may be possible to use the recent Iowa case there. I refer to the Whitmore *vs.* Herrick, (218 N.W.R., 335) case. I was out there at the trial, and felt that I helped win it. *Res ipsa loquitur* was barred and the verdict of the trial court was upheld by the Iowa Supreme Court. Also McCoy *vs.* Buck, an Indiana case (157 N.E.R., 456), where this same doctrine was denied, may help some.

"If we are unable to secure or present any evidence that defendant did receive x-ray treatment elsewhere, I am of the

opinion that it will be very desirable to show by witnesses that the machine had been recently calibrated, and this can be done by two competent men, according to what Dr. T. told me. It will, of course, be advisable to prove by an overwhelming amount of expert testimony that the dosage given by the defendant was not excessive. I am a native of that State, having lived there for something like thirty-eight years and know the minds of the people out there pretty well. The city where the trial will occur is a University town, where higher education is highly thought of and given high standing and credence. A jury will listen to and give full weight to the testimony of experts who can qualify to the limit, and as this is a case for experts, I advise that plenty of expert testimony be presented. I say get plenty, get good ones, and use them to the limit. Hammer home that sort of testimony repeatedly, reiterating again and again that the dosage was correct, that it should not have done damage, etc., and you will have a chance to win this case."

The next day, I wrote defendant as follows: "My Dear R., when I read your deposition, submitted to me by the insurance company, I was disappointed. Why did you admit that you used 200 kv. when your record showed (when you were here) that you used 180 kv.? And 150 instead of 130 kv? I know that there is no use howling now, so suppose we let it rest as you testified, but it is really too bad, because that may make a big difference in the out come of the entire affair.

"I am sending you herewith a carbon copy of my letter of yesterday to the insurance company, which contains some things that may have quite a bearing upon how best to fight this case. They (the insurance company) usually have me write them such a letter, at the beginning of the litigation regarding x-ray dermatitis cases, and evidently have found it worth while to do so, as they continue to have me do it. You, of course, understand that anything I say therein has absolutely no personal bearing, and is absolutely confidential. They will see that your attorneys get a copy of my letter.

"In the letter to the insurance company, you will notice a casual mention of Dr. B. I do not know just why I did it, but last Thursday before the meeting of the Chicago Roentgen Society, I asked him if he had heard about your case. He spoke up with 'Yes, did they come to see you too?' When I asked him who he meant by 'they,' he told me that a firm of lawyers here had brought a copy of your affidavit to him and wanted him to make an affidavit that the technic used by you was wrong, and not according to the usual and most approved practice, etc. After calling his attention to the particulars in this case and some connected incidents he decided that he would have nothing to do with the entire matter. Evidently the plaintiff's local attorneys are after testimony and while I have good reason to believe that almost anyone except X. would call me before doing anything, I would not be surprised if they got some one (or more) to give or sell them what they want, particularly as they are prepared to pay for it. Of course, if I get at the men first, they will think twice before doing it, but I may not get at them.

"I have yours relative to what you have done regarding the G. Hospital in W., and think that your way of doing it is best. Let me know as soon as you have a reply, and in the meantime try to get F. to remember where defendant said he received the other treatment.

"Trusting that you will come out of this mess with colors flying, even if you do have a few after-pains," etc.

A few days later, after a letter from defendant, I wrote the following: "While I know Dr. T. by sight, and he probably knows me the same way, I have no speaking acquaintance with him, but I think that it will be easy enough to have your Mr. D. secure an interview with him. I believe that I can readily arrange that. Dr. T. is an urologist and g.-u. surgeon, and . . . .

"I have been doing some digging in the literature and find quite a few things that have not, as far as I can learn, been injected

into the defense of an x-ray dermatitis case before. Among the new things are:

"Syphilis has been known to sensitize the human skin to radiation. So if a patient has syphilis, he may develop roentgen or other radiation reactions more readily than a non-syphilitic.

"Porphyrinuria and porphyrinemia, due to taking some of the commonly used synthetic sedatives and sleep producers, produce a lessened sensitivity to radiation. Dr. Rollin H. Stevens, of Detroit, can give you more relative to this subject than any one I know.

"Buckwheat also produces a sensitization to radiation, particularly in individuals of light complexion (your man is a blonde). This is due to the porphyrin content. A Dr. Betz took 0.2 gram of porphyrin in October and suffered a "light stroke" from exposure to ordinary sunlight, the following December.

"Another important fact, which might be important in this case is that porphyrin products in the circulation, in addition to producing a sensitization to light, also cause itching. Sulphonal and luminal produce porphyrinemia and porphyrinuria, with sensitization to light and x-rays.

"The use of ointments and topical applications containing tar are known to sensitize to x-rays, and fluorescent substances like eosin and quinine when used either externally or taken internally, sensitize to the x-rays. Salvarsan and its products also sensitize to light *and probably to x-rays.*

"I am calling your attention to these items so that you may have them looked up. If they are found to be of any use in the case, get the material into shape to use. As previously stated, Stevens probably knows more about the porphyrin skin sensitization than any man in the country. You will remember him from the Panama trip. I have spoken to him about your case, and he said that he will be glad to do anything within his ability to help."

After considerable further investigation and extensive correspondence, we were unable to find out where the plaintiff in this case received any more x-ray treatment, although he had told the surgeon who operated upon the damaged region that he had received same. In a great measure because of the prominence of the plaintiff as well as the undesirabity of the great notoriety the defendant would receive if the case went to trial, it was deemed advisable to settle out of court and before trial. The case was therefore settled for $8,700.

PHYSICIAN'S OR TECHNICIAN'S RESPONSIBILITY

The problem as to whether a physician or his technician is responsible for injuries resulting from errors, omissions, or carelessness of the technician, and the consequent application of the law of agency, which in so many words states that the principal is responsible for the acts of his agent; or the law of master and servant, which generally applies in such cases, and involves the maxim "*respondeat superior*," which, liberally interpreted means, *the master is responsible*, comes up frequently in our work.

A radiologist in an eastern State informed me that both he and the hospital where he was employed as roentgenologist were threatened with a malpractice suit because of an alleged injury resulting from a patient receiving an electric shock in the x-ray department, while a technician was preparing to make a roentgen examination of an injured wrist.

He stated that he was practising roentgenology in the hospital, on a part-time basis for a fixed salary, and had assumed that the hospital would be held liable if any malpractice suit were brought.

He asked, "What can you tell me as regards my liability? I have no malpractice insurance." My reply was necessarily somewhat equivocal because of the vagueness of his information. He was apparently in considerable distress and wanted something, one way or the other, to relieve the doubt or questionable situation, so I immediately replied:

"*Bis dat qui cito dat!*" Replying to yours of last Saturday, will say that your liability depends upon several things,

among which are, whether the technician who was careless and who caused the alleged injury, was *in your employ* or in the employ of your employer, the hospital; whether she was acting as your agent, and you were responsible for her acts; or whether she was entirely under the control of the hospital, and you had no responsibility or control over her conduct or acts while in the roentgen department at the time the alleged accident occurred.

"If the technician was acting as *your agent*, both you and the hospital may be held liable, while if she was neither your employee nor your agent, it is decidedly unlikely that you will be held responsible. This is particularly true if you were not present when the injury occurred, but that of itself is open to some question and debate.

"It is usually considered good logic that physicians do not become responsible for acts of nurses or technicians, when such acts as are brought into question constitute duties usually and normally performed and included in the regular duties of nurses and technicians. This is particularly true if the nurse or technician be not in the employ and under the specific directions of the physician, or in such a situation where the relation of employer and employee or as the law sees it 'master and servant' does not exist. If, as already intimated, the relation of 'master and servant' does exist, the maxim of '*respondeat superior*,' or 'the master is responsible,' applies, if and when the act performed involves some portion of the duties of the employee while acting as such employee.

"It has been held by highly respected courts, that when a nurse, while performing the regular duties of her profession, does something or fails to do something which she should have done, the physician in charge of the case may not be held liable. For example, if while administering hypodermic medication a nurse breaks an hypodermic needle, and damage results, the physician who directed that she administer the hypodermic injection is not considered responsible and will not be held liable. This is because the administration of hypodermic injections is a part of the usual and regular duties of the professional nurse. On the other hand, if a lay person, not a licensed or graduate nurse, administers an hypodermic injection pursuant to the instruction or order of a physician and the breaking of a needle causes injury and damage, the physician is, should be, and would be held liable. This is because the person so doing the damage has no legal duty, right, or function as regards the act which caused the injury, and does the act as the agent of the physician, whose duty under the conditions just cited, was to administer the injection himself. The principal is responsible for the acts of his agent. Right here it may as well be stated that a principal may only be held responsible for the acts of his agent, if the acts of the agent are within the proper and authorized duties and acts of the principal. For example, if a veterinary surgeon were to direct that a nurse suture a wound or incision on a human being, the veterinarian would not be liable, provided, of course, he were not a physician for human ailments and ills. Likewise, if a physician directed a nurse to suture a wound, he would be liable for any injury or damage resulting from such act, because it is not a part of the usual and regular duties of a nurse to suture wounds, and the nurse when doing such suturing was acting as the agent of the physician.

"In Ragan *vs.* Zimmerman (206 Calif. R., 723; 276 Pac.R., 107) a dentist employed a technician to make roentgen examinations. While doing her work one day, a patient received an electric shock and burn. Suit was brought against the dentist, and the trial court gave the plaintiff a verdict and judgment for damages. The case was appealed to the Supreme Court of California (where this occurred) and where the judgment was confirmed, and the dentist had to pay.

"Witherington *vs.* Jennings, 149 N.E.R., 221, a Massachusetts case, is to all intents and purposes similar to yours unless I am in error. Dr. Jennings was the salaried, part-time roentgenologist in charge of that

department of a hospital. Meacham was a technician employed by the hospital. Dr. Jennings wrote a prescription for certain x-ray treatment to be administered to Mrs. Witherington. Meacham administered the treatment, but inadvertantly left out the filter, with the usual result. The patient sued the physician who prescribed the treatment, contending that he was responsible because he was the head of the x-ray department in the hospital.

"The trial court decided in favor of the defendant physician; but plaintiff appealed to the Supreme Court of Massachusetts, where the judgment of the lower court was affirmed.

"In that decision, the Supreme Court said: 'Meacham was not employed by the defendant; he was not the defendant's agent or servant. They were fellow employees of the — hospital. The defendant was not responsible for the neglect of Meacham in administering the treatment, which was entirely under his control. He did not participate in the operation and was not liable for the injury.'

"In a North Carolina case (Covington *vs.* Wyatt, 145 S.E.R., 673), where the State law requires that the physician or other person assisting at a birth, instill a silver solution into the eyes of a newly born infant, a graduate nurse employed by the hospital asked the attending physician if she should administer the drops to the baby's eyes. Upon being told that she should, she instilled several drops of a *30 per cent* solution of silver nitrate, instead of the regulation 1 per cent solution, with terrible results.

"The physician was sued for malpractice, and in the trial court a verdict with judgment was given the plaintiff. On appeal to the North Carolina Supreme Court, the judgment of the lower court was reversed. The latter court held that according to the law, the physician might apply the silver solution or he might direct the nurse to do it. The nurse having done it, while acting as an employee of the hospital, and not as the agent of the physician, and because it was a part of the duties of nurses to instill drops into the eyes, the physician was therefore not liable.'

"In another case[2]— this one in Seattle— a physician directed a nurse to inject ergot hypodermically. An abscess resulted and the physician was sued for malpractice. The trial court brought in a verdict in favor of the physician defendant. The plaintiff appealed the case to the Supreme Court of Washington, where the judgment of the lower court was affirmed, 'because the giving of hypodermic injections, under physician's orders, by hospital nurses is a part of nursing,' and because the nurse was an employee of the hospital and not acting as the physician's agent.

"In Runyan *et al. vs.* Goodrum, an Arkansas case, involving the question of 'master and servant,' the Supreme Court of that State said (Feb. 21, 1921), that: 'Hospital owners and roentgenologists are not responsible for carelessness of x-ray technicians.'

"In Gross *vs.* Robinson (218 S.W.R., 924), a Missouri case, the Supreme Court of that State decided that the rule of '*Respondeat superior*' does not apply. I am sure that it will be very much worth your while to have this decision reviewed.

"In Phillips *vs.* Buffalo General Hospital (146 N.E.R., 199), a New York case, it was held that the 'hospital is not held responsible for neglect of an orderly.'

"I believe that I have given you sufficient references to set your attorneys searching, and probably more than they will want or need."

Recent inquiry from the radiologist to whom the foregoing long letter was written, elicited the following: "I had almost entirely forgotton about that threatened malpractice suit when I received your letter a few days ago. I am glad to inform you that when the patient consulted his lawyer, and the latter visited me, and I showed him your letter he decided not to take the case and advised the patient not to sue me. So he did not sue and we were relieved of a rather disagreeable mess.

[2] Thompson *et ux. vs.* Virginia Mason Hospital *et al.*, 277 Pac. R., 69.

But I assure you that I now carry malpractice insurance, thanks to your advice."

The fact that this radiologist "had almost forgotten about that threatened malpractice suit," etc., is quite the usual thing. Most of us are far too prone to forget ominous or threatening incidents as soon as they pass.

X-RAY PAPER: ARE ROENTGENOGRAMS ON IT ADMISSIBLE IN EVIDENCE?

About two years ago, a roentgenologist in a central State asked me in a letter "if roentgenograms made on x-ray paper could be introduced and properly recognized in legal procedures, or, in other words, would they be admitted in evidence?" I replied:

"While I have not heard that that question has ever been raised, either in court or out of court, it seems to me that it can make no difference legally what kind of substance serves as a supporting medium for the silver emulsion which produces the roentgenogram.

"I can conceive of no good reason why either glass, celluloid, cellophane, cloth, or paper may not be used to support or carry the chemicals which produce the representation of what the roentgen rays portray. It is my impression that it is not the glass, celluloid, paper, or what have you that makes the roentgenogram valuable as a diagnostic medium and as such, useful in evidence to prove certain facts in court. To my notion, and I think that every sensible person will back me up, it is the silver salt, which has been first acted upon by the roentgen rays and then by the chemicals in the dark room that is the all-important element in the roentgenogram.

"Therefore, if my opinion is worth anything, I say unqualifiedly and without reservation that roentgenograms made upon x-ray paper or other photographic paper, should be and would be admitted in evidence just as freely and legally as would any glass or celluloid roentgenograms.

"I have used the paper a few times in cases where they may have to be introduced in court, and if I do introduce them, I fully expect to have no trouble because they are made on paper.

"In reply to your postscript as regards my personal opinion of the 'paper films,' that is entirely another matter.

"Something like twenty-odd years ago, our late lamented friend, George Brady, brought out his Paragon X-ray Paper, which after a trial of a few months he found was not very well received, and he soon dropped its production. I tried it at that time and like many others advised George to drop it, and stuck to plates until the duplitized films made their appearance. Then more recently some of the manufacturers thought that they had something real good, and they brought out the present line of x-ray paper.

"After trying all the available makes and brands of x-ray paper I am still using celluloid films. It appears to me that the only advantage that any of the papers have is cheapness and because the difference in the prices means at most only a few cents in each case, in view of the undeniable and undisputed facts that the celluloid films give us the maximum detail, as compared to paper and that the transparent character of the celluloid films permits of a more critical and careful study of the finer tissue changes as compared to the translucent paper, I consider the celluloid films decidedly superior and preferable.

"The Minnesota Radiological Society decided against the use of paper in 1934, and at the meeting of the Radiological Society in Memphis in December, 1934, resolutions discouraging the use of x-ray paper were introduced by a Minnesota radiologist, and I believe adopted."

The roentgenologist who asked the question about paper later wrote me that an attorney had told him that he was going to object to the introduction of paper roentgenograms in a case, but who, when shown my letter, informed him that he would not make the objection. The writer is very desirous of learning if any of the readers hereof have found any legal difficulties with paper roentgenograms.

(*To be continued*)

AN INVESTIGATION OF X-RAY FILMS AND DEVELOPING SOLUTIONS[1]

By CHARLES WEYL, S. REID WARREN, JR., *and* DALLETT B. O'NEILL,
Philadelphia

From the Moore School X-ray Laboratory, Moore School of Electrical Engineering, University of Pennsylvania

INTRODUCTION

THE maintenance of a high standard of roentgenographic output depends upon the following general factors:

1. Calibration and positioning of the patient;
2. Characteristics of permanent equipment such as power supply lines and transformers, high voltage generating apparatus, x-ray tube, intensifying screens, cassettes, and viewing apparatus;
3. Films and processing materials and methods;
4. Roentgenographic technic.

The first factor presents a problem which at the present time has not been completely solved. No precise scientific method of determination of the x-ray absorption characteristics of the patient has been perfected for routine clinical application.[2] This will necessarily result in some variation in the roentgenographic quality, but the magnitude of this variation may be greatly reduced by careful measurement of the thickness of the part being roentgenographed and experienced qualitative estimation of the type of the structure of this part.

The items listed under the second factor are considered as permanent equipment, with reference to films and processing materials which are being replaced almost continuously. Sufficient information concerning these items is available[3] to provide a sound basis for their scientific choice. With this equipment installed, calibrated and operated with care and precision, the roentgenographic output will be determined chiefly by the films, processing materials and methods, and the roentgenographic technic employed.

The criteria of the roentgenographic output are the photographic densities of the finished film. Density is that characteristic of an area of exposed and processed film which describes the relation between the intensity I_0 of light incident upon the film to the intensity I_1 of light transmitted through the area. Density $D = \log_{10}\frac{I_0}{I_1}$, which is a positive pure number. It has been shown[4] that in general maximum interpretability of a roentgenogram is obtained when the density of the lightest portion of the diagnostic area is no less than 0.4 and the density of the darkest portion of the diagnostic area is no greater than 1.5. Therefore, it is desirable to use films, developing solutions and processing methods, and a roentgenographic technic which will permit the most efficient production of the densities in this range.

The speed of a film or developing solution determines the exposure necessary to produce a given density in the finished film. As the speed increases the exposure neces-

[1] This investigation was conducted at the Moore School of Electrical Engineering, University of Pennsylvania, under a special grant by the Faculty Research Committee of the University of Pennsylvania. The Moore School X-ray Laboratory, in which these tests were made, operates under a grant to the University of Pennsylvania by the National Tuberculosis Association.

[2] An investigation is being made at the Moore School X-ray Laboratory of a practical, scientific method of determining the x-ray absorption characteristics. It depends primarily upon the comparison between the ionization effects of two identical beams of x-rays, one of which impinges directly upon the ionization chamber, the other of which is intercepted by the patient before traversing the ionization chamber.

[3] Charles Weyl and S. Reid Warren, Jr., Apparatus and Technique for Roentgenography of the Chest, Chap. 2, Charles C. Thomas, 1935.

[4] Charles Weyl and S. Reid Warren, Jr., Apparatus and Technique for Roentgenography of the Chest, page 39, Charles C. Thomas, 1935.

sary to produce this given density decreases. Consequently it is advantageous to employ a film and developing solution having high speed characteristics. The contrast characteristic determines the difference in the densities produced by exposures having a given ratio.[5] As the contrast increases, the density difference for the given exposure variation also increases. In making a roentgenogram of a patient the variation of exposure over the film is caused by the difference in absorption in the various parts of the patient. Thus the greatest exposure and greatest density are obtained in the shadow of the least absorbing portion, while the least exposure and least density are found in the shadow of that portion which is most highly absorbing. If the ratio between the greatest exposure and the least exposure is held constant and the film contrast or contrast due to developing solution is increased, the resulting density difference increases. However, the exposure ratio depends upon the technic employed. A low x-ray tube voltage and high x-ray tube current technic produces a much greater exposure ratio with the same patient than a high x-ray tube voltage and low x-ray tube current technic. Since it is desired to obtain a roentgenogram having a maximum density of 1.5 and a minimum density of 0.4 in the diagnostic area, this density difference may be obtained with a combination of low contrast characteristics of film and developing solution and a low voltage, high current technic, or with high contrast characteristics and a high voltage, low current technic. But the x-ray tube efficiency increases as the x-ray tube voltage increases. Therefore, it is desirable to employ a film and developing solution with the greatest possible contrast to permit the use of the highest x-ray tube voltage which will produce the required density difference.

When films and developing solutions having high speed and contrast characteristics have been chosen and correct processing methods adopted, it is possible to establish an optimum roentgenographic technic for any type of roentgenography. The roentgenographic output then should be of the highest possible quality. Of even greater importance, however, is the maintenance of this high standard. Proper maintenance requires:

1. Careful, precise control of all operations both in the roentgenographic room and in the dark room;
2. A thorough and accurate check of all equipment and calibrations at regular intervals;
3. A supply of film and of developing solution powders whose speed and contrast characteristics remain constant over reasonable periods of time.

From the above discussion it may be seen that there are many problems involved in the routine production of high quality roentgenograms. Important among these is the choice and correct use of films and developing solutions, and in addition to their inherent importance is the complexity introduced by the continual replacement by fresh supplies.

It is the purpose of this investigation to consider the problems associated with films and developing solutions.

Since the unsharpness caused by grain in any modern brand of film is so slight that it is completely masked by the unsharpness resulting from finite focal spots, intensifying screen crystals and motion of the parts of the patient being roentgenographed, it may be seen that film grain is not a factor in roentgenography. The important criteria in the choice of films and developing solutions are the speed characteristics, contrast characteristics, and the constancy of these characteristics; and of the three criteria the last is probably the

[5] In the range of densities of interest, *i.e.*, 0.4 to 1.5, the density is approximately proportional to the logarithm of the exposure so that the density difference resulting from exposures A and B is:

$D_A - D_B = K \log A - K \log B = K (\log A - \log B)$

where K is a constant of proportionality. But

$$\log A - \log B = \log \frac{(A)}{(B)}$$

Therefore

$$D_A - D_B = K \log \frac{(A)}{(B)}$$

Thus, the density difference is determined not by the exposure difference but by the exposure ratio.

most important. In order to develop simple and accurate methods for the quantitative determination of these criteria, and to investigate processing methods, three makes of film and three brands of developing solution were tested. In Section A below there is described the first part of this investigation, from the results of which optimum processing conditions are determined and some important characteristics of films and developing solutions are observed. From the analysis of the results of Section A methods for determining the desired criteria are devised. In Section B these determinations are made for the three makes of film and the three types of developing solution being tested.

SECTION A

The three makes of film chosen for the investigation are designated A, B, and C, and the three makes of developing solution are designated X, Y, and Z. A and X are made by one manufacturer, B and Y by another, and C and Z by a third. It was desired to make identical exposures on a sufficient number of strips of each of A, B, C so that each make of film could be developed in each brand of developing solution under each of the chosen developing conditions. The processing factors which could be varied were:

1. Concentration of developing solution;
2. Temperature of developing solution;
3. Time of development.

It was decided to vary the developing solution concentration and the time of development. Since the optimum temperature of the developing solution is determined by the nature of the chemical reactions involved it was considered most desirable to use only this optimum value. All developing solutions were stirred thoroughly and frequently to insure homogeneity.

Test Procedure.—The roentgenographic exposures were made with a four-valve x-ray apparatus supplying full wave rectified voltage to the x-ray tube. The apparatus had a capacity of 90 kv.p., 300 ma., and the x-ray tube was of the 19° line-focus type with an effective focal spot 5.0 mm. × 5.0 mm. The exposures were timed with a synchronous impulse timer. The technic used for all exposures was:

X-ray tube voltage, 80 kv.p.;
Average x-ray tube current. 100 ma.;
Time of exposure, $^1/_{10}$ second.;
Focal spot-film distance, 72 inches.

The x-ray tube voltage was measured with a sphere gap and the x-ray tube current was measured with a ballistic milliampere-second meter. The values so obtained, as well as the exposure time, were checked oscillographically.[6] The oscillographic recordings also checked the constancy of the wave form.

An aluminum ladder was used as the test object for all exposures. The ladder was composed of eight sheets of commercially pure aluminum, each 14 inches in length and $^1/_8$ inch thick. The widths of these sheets varied in steps of one-half inch from $^1/_2$ inch to 4 inches. They were arranged to provide a ladder having eight steps varying in thickness by $^1/_8$ inch, from $^1/_8$ inch to 1 inch, each step being 14 inches in length and $^1/_2$ inch wide. In making each exposure a strip of $^1/_8$ inch thick lead 14 inches long and $^1/_2$ inch wide was placed beside the ladder and parallel with it to provide for fog measurement. All exposures were made with the same bakelite front cassette in which were mounted a pair of intensifying screens.

Each piece of film to be exposed was cut to a width of 6 inches and a length of 14 inches and placed in the cassette. The aluminum ladder and lead strip were placed in contact with the front of the cassette and the x-ray tube so positioned that the focal spot was on a line perpendicular to the front of the cassette and passing through the center of the aluminum ladder. An exposure was made using the technic described above. The piece of film so exposed was processed, and the densities under each step were carefully measured across the film to check the uniformity of radiation.

[6] Charles Weyl, S. Reid Warren, Jr., and F. Maurice McPhedran, Methods of Measuring and Recording Roentgen-ray Tube Currents and Voltages, Am. Jour. Roentgenol. and Rad. Ther., December, 1931, **26**, 871.

No appreciable density variation could be found under any step within 3 inches of the center of the film. All strips used in this investigation were cut, therefore, from the middle 6 inches of each piece of exposed film.

Three pieces of each make of film were exposed in the manner described above and twelve strips $^1/_2$ inch in width were cut from the middle 6 inches of each piece of exposed film. In this way there were provided 36 strips, each 6 inches long and $^1/_2$ inch wide, of each type of film, all identically exposed.

Having decided to vary the developing solution concentration and the time of development, the following values were chosen for use in developing the films:

1. Developing solution concentration:
   a. Normal concentration;
   b. Three-quarters normal concentration;
   c. One-half normal concentration.
2. Time of development:
   a. Three minutes;
   b. Five minutes;
   c. Six minutes;
   d. Eight minutes;

By "normal concentration" is meant the concentration of the solution when prepared in accordance with the instructions of the manufacturer. The developing time normally used in routine processing is from five to six minutes with fresh developer.

One gallon of each of the three makes of developing solution was prepared in accordance with the instructions of the respective manufacturer. Exposed strips of each of the three brands of film were developed in each of the developing solutions for each of the development times at a developing solution temperature of 65° F. This procedure was repeated after diluting the developing solutions to obtain three-quarters normal concentration. After developing at three-quarters normal concentration, the developing solutions were diluted to one-half normal concentration and the developing procedure repeated.

When the strips were completely processed and dried the densities of all the steps of all strips were measured. The density measurements were made with a comparative photo-electric densitometer.[7]

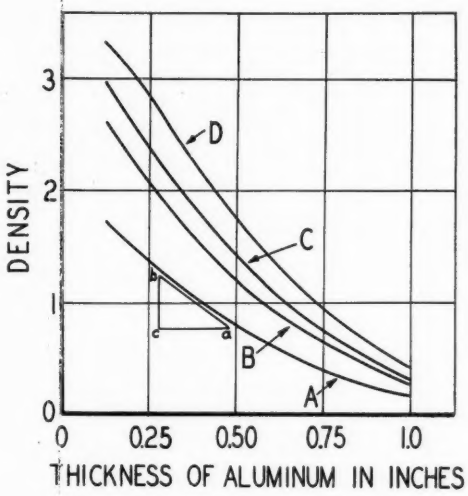


Fig. 1. Variation of density with thickness of aluminum. Film C; developing solution Z; normal concentration; time of development: A, 3 minutes; B, 5 minutes; C, 6 minutes; D, 8 minutes.

Results.—For each strip there was plotted a curve of density against thickness of aluminum, similar to those shown in Figure 1. As the thickness of aluminum increases the roentgenographic density decreases because of the increased x-ray absorption of the greater thicknesses. For purposes of comparison it is convenient to define the contrast for a particular thickness of aluminum as the slope of the density curve for that thickness of aluminum. For example, the contrast for $^3/_8$ inch of aluminum, curve A, Figure 1, is equal to the quantity

$$\frac{\text{(cb) density units}}{\text{(ca) inches of aluminum}} = 0.29 \text{ density units per } {}^1/_8 \text{ inch of aluminum.}$$

This definition is consistent with the discussion of contrast in the Introduction if comparisons are always made between contrasts evaluated for the same aluminum thickness. With this definition established, the

[7] Charles Weyl and S. Reid Warren, Jr., Apparatus and Technique for Roentgenography of the Chest, page 112, Charles C. Thomas, 1935.

contrast may be obtained for any point on any curve of density against thickness of aluminum.

sponding curves for the other makes of film and developing solution have similar form, the data necessary for the purposes of this

APPENDIX 1, TABLE I.—DENSITY AND CONTRAST FOR 3/8 INCH OF ALUMINUM

Film	Developing Solution	Concentration	Density 3 min.	Density 5 min.	Density 6 min.	Density 8 min.	Contrast 3 min.	Contrast 5 min.	Contrast 6 min.	Contrast 8 min.
A	X	1	0.96	1.49	1.80	2.20	0.27	0.36	0.48	0.57
A	X	3/4	1.05	1.67	1.91	2.26	0.27	0.37	0.44	0.51
A	X	1/2	1.01	1.63	1.87	2.14	0.25	0.39	0.40	0.48
A	Y	1	1.19	1.81	2.10	2.30	0.24	0.47	0.54	0.54
A	Y	1/2	1.03	1.62	1.83	2.06	0.23	0.33	0.38	0.41
A	Z	1	1.13	1.80	1.94	2.34	0.28	0.46	0.53	0.57
A	Z	1/2	0.99	1.58	1.80	2.18	0.26	0.32	0.38	0.50
B	X	3/4	0.82	1.44	1.72	2.20	0.24	0.31	0.40	0.44
B	X	1/2	0.75	1.29	1.52	2.03	0.20	0.25	0.31	0.38
B	Y	1	1.04	1.74	2.01	2.43	0.21	0.37	0.42	0.49
B	Y	3/4	1.01	1.64	1.87	2.36	0.21	0.32	0.36	0.40
B	Y	1/2	0.82	1.38	1.63	2.14	0.19	0.25	0.27	0.33
B	Z	1	1.04	1.56	1.78	2.34	0.20	0.33	0.43	0.54
B	Z	3/4	0.89	1.47	1.66	2.11	0.22	0.27	0.30	0.42
B	Z	1/2	0.79	1.31	1.55	1.84	0.21	0.25	0.32	0.34
C	X	1	0.86	1.42	1.64	2.05	0.27	0.38	0.49	0.55
C	X	3/4	0.97	1.54	1.81	2.15	0.25	0.39	0.48	0.54
C	X	1/2	0.84	1.40	1.60	1.94	0.24	0.32	0.38	0.47
C	Y	1	1.17	1.81	2.00	2.26	0.28	0.44	0.48	0.54
C	Y	3/4	1.15	1.67	1.90	2.22	0.26	0.38	0.43	0.47
C	Y	1/2	0.92	1.44	1.59	1.93	0.22	0.28	0.34	0.40
C	Z	1	1.05	1.60	1.85	2.25	0.29	0.44	0.54	0.56
C	Z	3/4	1.05	1.54	1.76	2.07	0.28	0.35	0.45	0.46
C	Z	1/2	0.75	1.32	1.53	1.84	0.22	0.33	0.34	0.45

APPENDIX 1, TABLE II.—DENSITY AND CONTRAST FOR 5/8 INCH OF ALUMINUM

Film	Developing Solution	Concentration	Density 3 min.	Density 5 min.	Density 6 min.	Density 8 min.	Contrast 3 min.	Contrast 5 min.	Contrast 6 min.	Contrast 8 min.
A	X	1	0.54	0.86	1.05	1.23	0.16	0.28	0.31	0.36
A	X	3/4	0.61	1.02	1.20	1.37	0.18	0.28	0.31	0.34
A	X	1/2	0.59	0.96	1.16	1.24	0.17	0.31	0.31	0.34
A	Y	1	0.71	1.06	1.21	1.35	0.22	0.31	0.35	0.37
A	Y	1/2	0.62	0.99	1.11	1.29	0.18	0.28	0.33	0.34
A	Z	1	0.68	1.08	1.13	1.34	0.19	0.30	0.32	0.39
A	Z	1/2	0.56	0.99	1.14	1.36	0.17	0.29	0.29	0.33
B	X	3/4	0.42	0.84	..	1.32	0.14	0.29	..	0.38
B	X	1/2	0.39	0.75	0.93	1.26	0.14	0.25	0.28	0.33
B	Y	1	0.62	1.08	1.25	1.55	0.19	0.30	0.31	0.37
B	Y	3/4	0.59	1.04	1.21	1.50	0.19	0.28	0.31	0.37
B	Y	1/2	0.50	0.90	1.09	1.40	0.14	0.25	0.27	0.34
B	Z	1	0.60	0.93	1.08	1.37	0.22	0.30	0.30	0.36
B	Z	3/4	0.50	0.90	1.05	1.37	0.16	0.27	0.31	0.35
B	Z	1/2	0.44	0.83	0.95	1.21	0.13	0.23	0.30	0.31
C	X	1	0.44	0.77	0.88	1.12	0.14	0.28	0.31	0.37
C	X	3/4	0.52	0.86	1.03	1.26	0.19	0.30	0.33	0.36
C	X	1/2	0.46	0.82	0.95	1.18	0.14	0.26	0.29	0.33
C	Y	1	0.68	1.07	1.20	1.32	0.22	0.31	0.32	0.34
C	Y	3/4	0.68	1.03	1.15	1.32	0.20	0.29	0.32	0.38
C	Y	1/2	0.54	0.93	1.02	1.24	0.16	0.25	0.25	0.30
C	Z	1	0.56	0.92	1.05	1.29	0.19	0.30	0.33	0.39
C	Z	3/4	0.58	0.90	1.06	1.26	0.20	0.30	0.30	0.34
C	Z	1/2	0.42	0.76	0.92	1.14	0.11	0.23	0.28	0.30

In Figure 1 there are shown four curves corresponding to the four developing times used for a given make of film, C, and a given make of developing solution, Z, at normal concentration. Since the corre-

investigation were obtained by considering three points on each curve. The three points chosen were those corresponding to thicknesses of aluminum of 3/8 inch, 5/8 inch, and 7/8 inch, respectively. These

thicknesses produce densities, for normal developing solution concentration and average time of development of from five to six minutes, which fall approximately at the two extremes and the middle of the useful density range of 0.4 to 1.5. This method of abstracting the required data eliminates the necessity for reproducing all the curves and permits the presentation of the data in tabular form. These data are presented in the four tables in Appendix 1. In tables I, II, and III the values of density and contrast for $^3/_8$ inch, $^5/_8$ inch, and $^7/_8$ inch of aluminum are recorded. Table IV contains the fog values obtained in the shadows of the lead strip.

From Tables I, II, III, and IV there are drawn curves of density against time of development and contrast against time of development for each of the three aluminum thicknesses, and also fog against time of development. In Figures 2, 3, and 4 there are shown curves of density, contrast, and fog, respectively, against time of development plotted from the data corresponding to the curves of Figure 1 for film C, developing solution Z, and normal developing solution concentration. These curves show that there is no reason for using a developing time less than five minutes since this would result in much lower density and contrast with very little diminution of fog. A developing time greater than six minutes produces a less rapid increase in density except for the very

APPENDIX 1, TABLE III.—DENSITY AND CONTRAST FOR $^7/_8$ INCH OF ALUMINUM

Film	Developing Solution	Concentration	Density 3 min.	Density 5 min.	Density 6 min.	Density 8 min.	Contrast 3 min.	Contrast 5 min.	Contrast 6 min.	Contrast 8 min.
A	X	1	0.29	0.42	0.54	0.62	0.09	0.13	0.20	0.25
A	X	$^3/_4$	0.33	0.53	0.65	0.80	0.11	0.21	0.23	0.25
A	X	$^1/_2$	0.31	0.46	0.61	0.64	0.10	0.18	0.23	0.25
A	Y	1	0.36	0.54	0.64	0.74	0.14	0.21	0.22	0.25
A	Y	$^1/_2$	0.33	0.50	0.56	0.71	0.11	0.20	0.22	0.25
A	Z	1	0.36	0.59	0.59	0.69	0.13	0.19	0.20	0.26
A	Z	$^1/_2$	0.30	0.51	0.61	0.78	0.10	0.18	0.23	0.25
B	X	$^3/_4$	0.22	0.40	..	0.67	0.07	0.16	..	0.28
B	X	$^1/_2$	0.20	0.36	0.44	0.68	0.06	0.14	0.16	0.26
B	Y	1	0.33	0.54	0.72	0.92	0.11	0.22	0.22	0.30
B	Y	$^3/_4$	0.33	0.56	0.65	0.89	0.10	0.19	0.22	0.26
B	Y	$^1/_2$	0.28	0.46	0.58	0.83	0.08	0.15	0.22	0.26
B	Z	1	0.30	0.46	0.56	0.73	0.10	0.18	0.22	0.27
B	Z	$^3/_4$	0.25	0.46	0.52	0.74	0.09	0.16	0.22	0.28
B	Z	$^1/_2$	0.23	0.42	0.45	0.61	0.08	0.15	0.17	0.25
C	X	1	0.22	0.36	0.40	0.51	0.09	0.14	0.16	0.24
C	X	$^3/_4$	0.26	0.40	0.47	0.61	0.10	0.15	0.20	0.28
C	X	$^1/_2$	0.23	0.39	0.46	0.57	0.08	0.16	0.20	0.26
C	Y	1	0.34	0.54	0.64	0.74	0.12	0.21	0.22	0.24
C	Y	$^3/_4$	0.35	0.54	0.59	0.74	0.13	0.20	0.24	0.25
C	Y	$^1/_2$	0.29	0.50	0.55	0.70	0.10	0.17	0.21	0.24
C	Z	1	0.29	0.44	0.50	0.65	0.11	0.16	0.21	0.26
C	Z	$^3/_4$	0.28	0.44	0.54	0.68	0.11	0.16	0.23	0.25
C	Z	$^1/_2$	0.24	0.40	0.45	0.59	0.07	0.16	0.18	0.22

APPENDIX 1, TABLE IV.—FOG

Film	Developing Solution	Concentration	3 min.	5 min.	6 min.	8 min.
A	X	1	0.11	0.14	0.15	0.18
A	X	$^3/_4$	0.11	0.17	0.18	0.21
A	X	$^1/_2$	0.13	0.15	0.16	0.17
A	Y	1	0.13	0.16	0.18	0.21
A	Y	$^1/_2$	0.12	0.13	0.15	0.18
A	Z	1	0.14	0.16	0.15	0.19
A	Z	$^1/_2$	0.12	0.15	0.17	0.21
B	X	$^3/_4$	0.10	0.14	..	0.17
B	X	$^1/_2$	0.11	0.11	0.13	0.17
B	Y	1	0.11	0.16	0.20	0.26
B	Y	$^3/_4$	0.12	0.18	0.20	0.30
B	Y	$^1/_2$	0.12	0.15	0.16	0.22
B	Z	1	0.12	0.14	0.16	0.22
B	Z	$^3/_4$	0.11	0.16	0.15	0.20
B	Z	$^1/_2$	0.11	0.13	0.14	0.16
C	X	1	0.07	0.08	0.09	0.09
C	X	$^3/_4$	0.07	0.09	0.09	0.10
C	X	$^1/_2$	0.07	0.08	0.09	0.09
C	Y	1	0.07	0.09	0.14	0.18
C	Y	$^3/_4$	0.08	0.10	0.11	0.17
C	Y	$^1/_2$	0.07	0.09	0.10	0.15
C	Z	1	0.08	0.09	0.09	0.12
C	Z	$^3/_4$	0.08	0.09	0.10	0.14
C	Z	$^1/_2$	0.09	0.08	0.09	0.10

low densities under $^{7}/_{8}$ inch of aluminum and a much less rapid increase in contrast, especially for the $^{3}/_{8}$ inch and $^{7}/_{8}$ inch aluminum thicknesses, while the fog is beginning to increase very rapidly. Since increased development time may also result in shorter developing solution life, it seems inadvisable to employ a development time greater than six minutes. The choice of developing time, therefore, lies in the interval between five and six minutes, and it would appear preferable to use six minutes in view of the increased density and contrast without appreciable increase of fog. While the life of the developing solution may be less if six-minute developing time is used, the load on the x-ray tube will be decreased with a consequent lengthening of its life. The data for film C and developing solution Z at normal concentration have been presented and interpreted. The data for the other films and developing solutions exhibit the same characteristics.

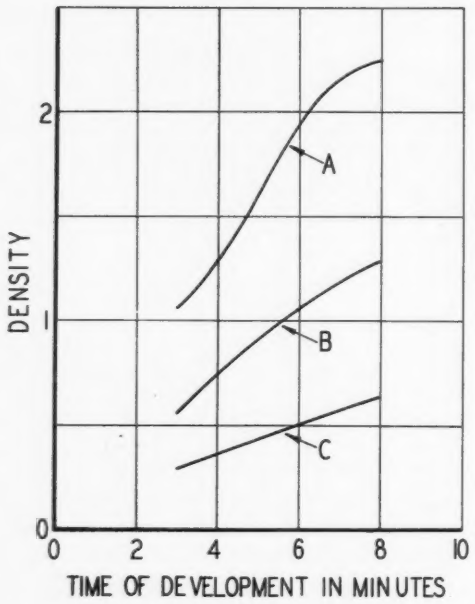


Fig. 2. Variation of density with time of development. Film C; developing solution Z; normal concentration; thickness of aluminum: A, $^{3}/_{8}$ inch; B, $^{5}/_{8}$ inch; C, $^{7}/_{8}$ inch.

In order to investigate the variation of density and contrast with variation of developing solution concentration the data for $^{5}/_{8}$-inch aluminum thickness and six-minute development time only were used, since the form of the variation was found to be independent of these two factors. Values of density and contrast for each make of developing solution and each value of de-

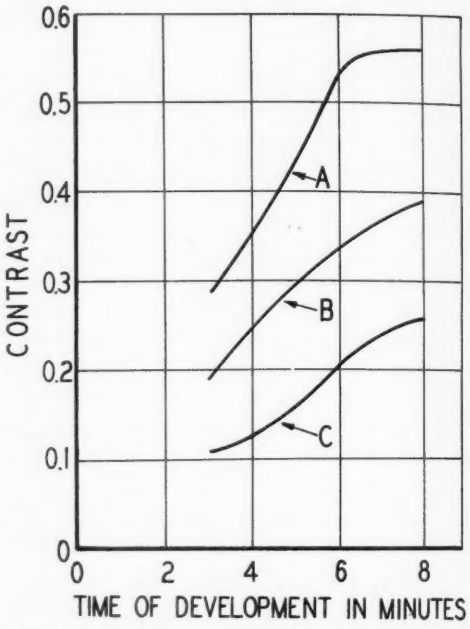


Fig. 3. Variation of contrast with time of development. Film C; developing solution Z; normal concentration; thickness of aluminum A, $^{3}/_{8}$ inch; B, $^{5}/_{8}$ inch; C, $^{7}/_{8}$ inch.

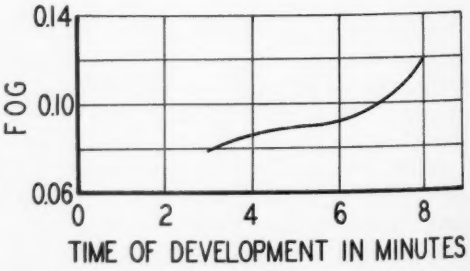
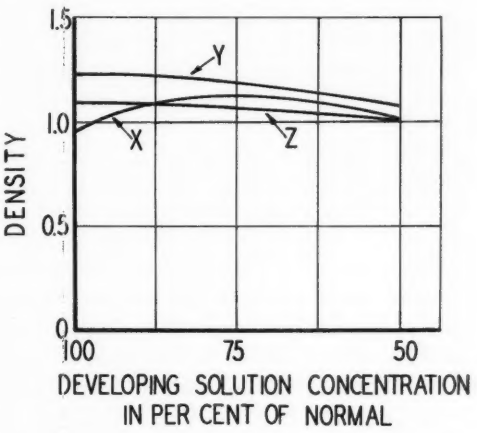


Fig. 4. Variation of fog with time of development. Film C; developing solution Z; normal concentration.

veloping solution concentration were computed by averaging the values obtained under each condition for the three makes of film. For example, the value of density for normal concentration of developing solution Z was obtained from the data in the following manner: Film A developed in developing solution Z for six minutes at normal concentration resulted in a density of 1.13 under $^5/_8$ inch of aluminum. Film B under the same conditions produced a density of 1.08, while for film C the density was 1.05. The average of these three densities is 1.09, and this average value was taken as the value of density for normal concentration of developing solution Z for the specified time of development and aluminum thickness. Density and contrast values for the various concentrations of all developing solutions were computed in the same fashion. Curves drawn from these computed values are shown in Figures 5 and 6. The most striking feature of these curves is the smallness of the variations in density and contrast as the value of the developing solution concentration varies from normal to one-half normal. This shows that in general the developing solution concentration is not a very critical factor when the solutions are fresh. However, while the effect of concentration on the life of the developer cannot be determined from these tests, several experiences in roentgenographic laboratories would indicate that the life is considerably shortened by reduction in solution concentration.

It is also interesting to note that developing solution X produces greater densities and contrasts for a concentration of three-quarters normal than for normal concentration. Developing solutions Y and Z produce decreasing densities and contrasts for decreasing developing solution concentration. This might indicate the advisability of a change in the quantities of some or all of the chemicals used in the preparation of developing solution X.

From the above discussion it may be seen that the data required for relative speed and contrast comparison of the three makes of film and the three makes of developer are the densities and contrasts produced by identical exposures for the three thicknesses of aluminum, $^3/_8$ inch, $^5/_8$ inch, and $^7/_8$ inch. Since the variations of density and contrast with time of development are all similar in form it is necessary to use the data for only



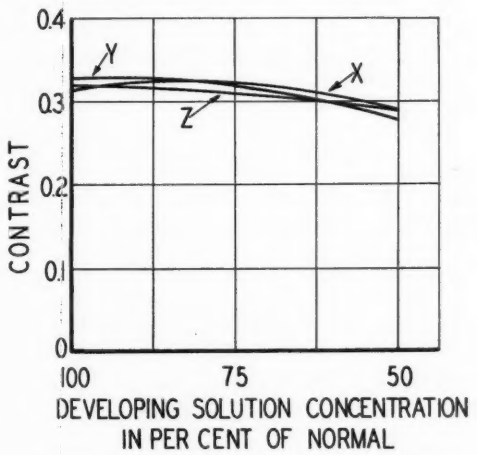


Fig. 5 (*above*). Variation of density with developing solution concentration for the three developing solutions X, Y, Z, used in the first test, Section A. Each value of density for each developing solution is the average taken over the three films for six-minute time of development, $^5/_8$ inch of aluminum.

Fig. 6 (*below*). Variation of contrast with developing solution concentration for the three developing solutions X, Y, Z, used in the first test, Section A. Each value of contrast for each developing solution is the average taken over the three films for six-minute time of development, $^5/_8$ inch of aluminum.

one time of development, for which six minutes has been chosen. And in spite of the singular results obtained with developing solution X, it is judged most fair to employ the data for normal developing solution concentration in making comparisons.

SECTION B

While the data obtained in Section A would suffice for a comparison of the speed and contrast characteristics of different makes of film and developer, further tests are necessary to determine the constancy of these characteristics. In view of the unusual characteristics of developing solution X with regard to variation of solution concentration, it was decided to incorporate in the tests for constancy a further study of the effect of varying developing solution concentration. The interval between the time of making the tests described in Section A and that for conducting the second set of tests was six months.

Test Procedure.—For the purposes of this test it was necessary to obtain strips of samples from new batches of the three makes of film having exposures identical with those given the strips in the previous tests. In this case, however, it was necessary to provide only nine strips of each make of film, since the time of development was to be held constant at six minutes. The procedure used in Section A was repeated in every detail, using the same x-ray apparatus, the same measurement and oscillographic apparatus, and the same cassette and screens. In addition, using the same procedure, three exposed strips of the original sample of film C were included to enable the two sets of tests to be correlated.

Samples from the new batches of the three makes of developing solution were prepared in the same manner as before, and the values of developing solution concentration chosen were the same: normal, three-quarters normal, and one-half normal. Before developing the strips of the three makes of film, the three exposed strips of the original sample of film C were developed, one in each developing solution, at normal concentration, a developing time of six minutes and a temperature of 65° F. Exposed strips of each of the three makes of film were then developed in each of the three developing solutions at each of the chosen values of developing solution concentration, with six-minute time of development and a temperature of 65° F. After processing and drying, all the steps of each of the developed strips were measured with the same comparative photoelectric densitometer which was previously employed.

Results.—Curves of density against thickness of aluminum were plotted for all film strips. The fog values and the density and contrast values for the three thicknesses of aluminum are presented in Appendix 2, Table I. It is now possible to make two separate comparisons of the relative speed and contrast characteristics of the three makes of film and of the three brands of developing solution, one comparison from the data obtained in Section A and the other comparison from the data on the new samples. Having developed exposed strips of the original sample of film C in the more recent samples of each of the three makes of developing solution, it is possible to correlate the two sets of data in such a way as to determine the variation of the speed and contrast characteristics of each make of film and each make of developing solution. These data also permit investigation of the effect of varying developing solution concentration. Any variations in this effect which have occurred in the six months' interval are obtained by comparing these data with the data of Section A.

Since the films were all identically exposed the most convenient method for expressing the relative speeds of any two makes of film or any two makes of developing solution is to use the ratio of the densities obtained in the two cases. The relative contrasts may be expressed in the same fashion. In Table A there are shown relative values of speed and contrast among the three makes of film and among the three makes of developing solution for each of the three thicknesses of aluminum used. The comparisons in Table A are for the original

samples tested in Section A. These comparisons and all those to be presented below refer to six-minute development and veloping solution are the averages taken over the three brands of film. It may be noticed that one make of film and one make

APPENDIX 2, TABLE I.—DENSITY, CONTRAST, AND FOG FOR SIX-MINUTE DEVELOPMENT TIME

Film	Developing Solution	Concentration	Density ⅜ in. Al	Density ⅝ in. Al	Density ⅞ in. Al	Contrast ⅜ in. Al	Contrast ⅝ in. Al	Contrast ⅞ in. Al	Fog
A	X	1	2.09	1.43	0.82	0.33	0.33	0.27	0.20
A	X	¾	1.83	1.24	0.71	0.32	0.28	0.24	0.19
A	X	½	1.53	1.05	0.61	0.25	0.23	0.21	0.16
A	Y	1	1.96	1.23	0.68	0.41	0.32	0.24	0.19
A	Y	¾	1.83	1.14	0.63	0.38	0.30	0.22	0.18
A	Y	½	1.52	0.98	0.55	0.30	0.25	0.19	0.16
A	Z	1	2.01	1.27	0.70	0.42	0.33	0.25	0.18
A	Z	¾	1.89	1.18	0.66	0.40	0.30	0.22	0.18
A	Z	½	1.59	1.01	0.57	0.33	0.26	0.19	0.16
B	X	1	2.14	1.23	0.60	0.47	0.40	0.25	0.18
B	X	¾	1.93	1.14	0.53	0.40	0.37	0.23	0.16
B	X	½	1.50	0.87	0.41	0.35	0.28	0.18	0.14
B	Y	1	1.98	1.05	0.52	0.57	0.35	0.20	0.19
B	Y	¾	1.79	0.99	0.49	0.42	0.33	0.18	0.18
B	Y	½	1.47	0.84	0.44	0.35	0.26	0.15	0.16
B	Z	1	2.02	1.09	0.49	0.51	0.40	0.20	0.16
B	Z	¾	1.86	0.98	0.44	0.47	0.36	0.19	0.16
B	Z	½	1.48	0.76	0.35	0.43	0.28	0.14	0.14
C	X	1	1.92	1.19	0.65	0.40	0.31	0.20	0.26
C	X	¾	1.69	1.06	0.61	0.37	0.27	0.18	0.23
C	X	½	1.43	0.88	0.50	0.32	0.23	0.16	0.20
C	Y	1	1.69	1.03	0.62	0.40	0.26	0.15	0.34
C	Y	¾	1.56	0.96	0.57	0.37	0.24	0.15	0.29
C	Y	½	1.38	0.87	0.52	0.30	0.22	0.14	0.24
C	Z	1	1.90	1.14	0.64	0.46	0.31	0.18	0.29
C	Z	¾	1.64	0.97	0.55	0.41	0.27	0.16	0.23
C*	X	1	1.82	1.01	0.51	0.51	0.33	0.17	0.21
C*	Y	1	1.57	0.88	0.48	0.44	0.27	0.14	0.26
C*	Z	1	1.61	0.84	0.44	0.52	0.28	0.14	0.20

* Sample of film C from original batch.

normal developing solution concentration, as previously discussed. The values employed to determine either speed or contrast for a particular make of film are the averages of the values obtained with this make of film developed in each of the three brands of developing solution. In the same way the values for a particular make of developing solution are always assigned a value unity for both speed and contrast. Since these comparisons are entirely relative among the different types of film and among the different types of developing solution, it is convenient to choose one product in each group as an arbitrary reference base. Film A and developing solution X have been arbitrarily chosen in the two cases. It can be clearly seen from these comparisons that throughout the useful exposure range film A and developing solution Y have both greater speed and greater contrast than their competitors. The criteria for choosing films and developing solutions for use in a roentgenographic laboratory have been discussed in the Introduction. With these criteria in mind the results obtained from the data of Section A indicate film A and developing solution Y to have been the optimum choice at that time.

TABLE A

Film and developing solution comparison at the beginning of the six-month interval for normal developing solution concentration and six-minute time of development. Film A and developing solution X are arbitrarily chosen as bases of reference for this relative comparison.

		⅜ in. Al		⅝ in. Al		⅞ in. Al	
		Speed	Contrast	Speed	Contrast	Speed	Contrast
Film	A	1.00	1.00	1.00	1.00	1.00	1.00
	B	0.92	0.78	0.98	0.93	0.96	0.98
	C	0.94	0.97	0.90	0.97	0.87	0.95
Developing Solution	X	1.00	1.00	1.00	1.00	1.00	1.00
	Y	1.22	1.08	1.30	1.06	1.47	1.24
	Z	1.11	1.13	1.16	1.03	1.21	1.18

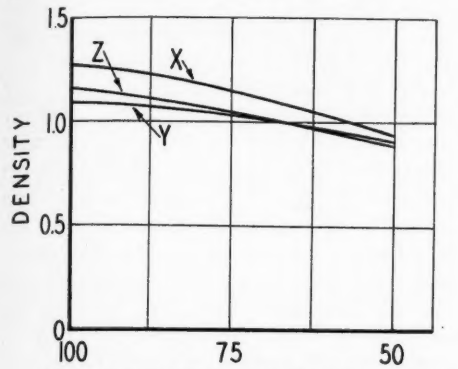
Two sets of data taken at the beginning and the end of the six months' interval, respectively, are used to determine the change in speed and contrast during this period for any combination of a particular make of film and a particular make of developing solution. In order to separate the film change and the developing solution change it is necessary to consider the data obtained by developing exposed strips of the original sample of film C in the new samples of the three makes of developing solution. Before comparing these data with the original data for film C it is necessary to make corrections for the changes in speed, contrast, and fog during six months' storage of this film. Correction was made for the increase in fog by deducting from each of the measured densities an amount determined by the increase in fog under the lead strip and the density from which the deduction was made. The presence of this latter factor is due to the variation of the effect of fog throughout the density range. The amount added by fog to low densities is greater than the amount added to higher densities. In accordance with well-known fog correction formulas,[8] one-half of the fog increase under lead was deducted from the densities for $^3/_8$ inch of aluminum, three-quarters of the increase from those for $^5/_8$ inch of aluminum, and seven-eighths of the increase from those for $^7/_8$ inch of aluminum. On the basis of private communication with a laboratory engaged in photometric work, the speed and contrast were assumed to have decreased by 20 per cent during six months' storage and correction was made by adding to the densities accordingly. Comparing these corrected data with the original data for film C, the change in each make of developing solution is determined. The film change and the developing solution change can then be separated.

It should be noted that while the figure of 20 per cent used in this computation is in some degree arbitrary and not to be considered precisely correct, any error introduced by this assumption will affect only the separation of the changes due to film and developing solution. The change in any combination of any film with any developing solution is completely determined from the data without the need for any assumption. The experience gained through this investigation indicates that the better method of separating film and developing solution changes consists of saving a portion of the chemicals used in preparing the original sample of one of the makes of developing solution and preparing a small amount of developer from these chemicals at the time of the next test. If the chemicals are kept tightly sealed in a cool place and the developing solution made from them in the proper amount to provide normal concentration, it should be possible to determine accurately the changes which have occurred in each make of film under investigation.

The results of the above computations are recorded in Table B for each of the three thicknesses of aluminum and for six-minute development time and normal developing solution concentration. The figures appearing in this table for speed or contrast variation for any particular make of film or developing solution represent the *ratio of the speed or contrast at the end of the six-month interval to that at the beginning of this time.* Examination of this table reveals variations in speed and contrast which in some cases are as great as from 25 to 30 per cent. These variations are in some cases increases, and in others they are decreases, and in general they are not uniform over the range from $^3/_8$ inch of aluminum to $^7/_8$ inch of aluminum. Film A, for example, exhibits decreases in both speed and contrast at $^3/_8$ inch of aluminum, while both speed and contrast have increased for $^7/_8$ inch of aluminum. Film B, on the other hand, has had an increase in speed and a very appreciable increase in contrast at $^5/_8$ inch of aluminum, while for $^7/_8$ inch thickness the speed has decreased and the increase in contrast is small. These variations are noted in practically every

[8] Jones, L. A., Photometric Sensitometry, Jour. Soc. of Motion Pic. Engs., **17** pp. 718–720.

make of film and developing solution during the six-month interval. Whether they represent a long-term trend or simply differences between two emulsions, the effect on the reproducibility of roentgenographic results is identical. Only in the instances of Film B and developing solution X are the variations of sufficient magnitude in the proper direction to be justified as an appreciable improvement in the manufacturer's product. The variations for the other makes of film and developing solution have no justification and can result only in waste and confusion.



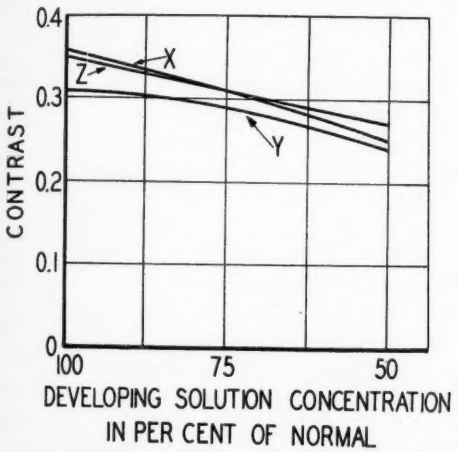


Fig. 7 (*above*). Variation of density with developing solution concentration for the three developing solutions X, Y, Z, used in the second test, Section B. Each value of density for each developing solution is the average taken over the three films for six-minute time of development, $^5/_8$ inch of aluminum.

Fig. 8 (*below*). Variation of contrast with developing solution concentration for the three developing solutions X, Y, Z, used in the second test, Section B. Each value of contrast for each developing solution is the average taken over the three films for six-minute time of development, $^5/_8$ inch of aluminum.

The investigation of the effect of varying developing solution concentration gives further evidence of changes in the various makes of developing solution. In Figures 7 and 8 there are shown curves of density and contrast, respectively, against developing solution concentration for each of the three makes of developing solution. These curves were obtained from the data in Appendix 2 in the same manner as those of Figures 5 and 6 were obtained from the data in Appendix 1. Comparison of the two sets of curves shows that developing solutions Y and Z have changed, now being more affected by changes in developing solution concentration than they previously were, but it is developing solution X which has changed most. This developing solution no longer produces greater densities and contrasts when diluted and it is now affected more than either Y or Z by variation of concentration. This change in developing solution X is undoubtedly closely related to the change observed in Table B.

TABLE B

Variation of speed and contrast during six-month interval expressed as the ratio of speed or contrast at the end of the interval to the speed or contrast at the beginning of this interval for six-minute time of development and normal concentration of developing solution.

		$^3/_8$ in. Al		$^5/_8$ in. Al		$^7/_8$ in. Al	
		Speed	Contrast	Speed	Contrast	Speed	Contrast
Film	A	0.94	0.75	1.15	0.91	1.27	1.15
	B	1.06	1.30	1.04	1.16	0.97	1.06
	C	0.92	0.85	1.06	0.85	1.25	0.90
Developing Solution	X	1.25	0.95	1.25	1.17	1.30	1.25
	Y	0.94	1.02	0.83	0.99	0.78	0.90
	Z	1.05	0.98	0.95	1.11	0.92	0.95

After noting the changes which have occurred it is particularly interesting to make a comparison of the various types of film and developing solution at the end of the six months' interval. The results of such a

comparison are recorded in Table C, the method for obtaining these results being identical with that used to obtain Table A.

TABLE C

Film and developing solution comparison at the end of the six-month interval for normal developing solution concentration and six-minute time of development. Film A and developing solution X are arbitrarily chosen as bases of reference for this relative comparison.

		3/8 in. Al		5/8 in. Al		7/8 in. Al	
		Speed	Contrast	Speed	Contrast	Speed	Contrast
Film	A	1.00	1.00	1.00	1.00	1.00	1.00
	B	1.01	1.34	0.86	1.17	0.73	0.89
	C	0.91	1.08	0.86	0.90	0.87	0.70
Developing Solution	X	1.00	1.00	1.00	1.00	1.00	1.00
	Y	0.92	1.15	0.86	0.89	0.88	0.82
	Z	0.97	1.16	0.91	1.00	0.88	0.87

The procedure of choosing for use in the roentgenographic laboratory a make of film and a make of developing solution from Table C is now more difficult than was the choice from Table A. The non-uniformity of the variations observed in Table B is responsible for this difficulty. For exposures under 3/8 inch of aluminum film B is obviously best, while for 7/8 inch of aluminum film A is much superior to film B. At 5/8 inch of aluminum the choice lies between a film having greater speed and one having greater contrast and since greater contrast will permit the use of a higher voltage and consequently more efficient technic film B is to be preferred. Thus it is seen that while film B is the better film over more than half the range its superiority is not too well defined. In the same manner developing solution X is to be preferred although developing solution Z has the advantage at 3/8 inch of aluminum.

Recommended Processing and Test Methods.—On the basis of the tests described in Section A it is concluded that the optimum processing conditions for fresh developer are:

1. Normal developing solution concentration (preparation according to manufacturer's instructions);
2. Developing solution temperature of 65° F.;
3. Development time of six minutes.

As the developing solution is used it is important that the level in the tank be maintained and the time of development be increased to compensate for deterioration.[9] The developing solution level is best maintained by the regular addition of small quantities of fresh developer to replace that which is carried away by the films or by evaporation. One pint of fresh developer should be added and stirred carefully after each group of ten 14 × 17 in. films, or the equivalent, are processed. The calibration of the developing solution involves the use of strips of one make of film which have been prepared in a manner identical with that described in Section A. One of the strips is processed for 6 minutes at 65° F. when the developer is fresh and used as a standard throughout the life of the developer. After about twenty-five films per five gallons of developer have been developed, three strips are processed for 6, 6.25, and 6.50 minutes. By measuring densities[10] of the steps and plotting curves like those shown in Figure 1 these strips are compared with the standard, and the development time which produces densities equivalent to those of the standard strip is adopted for the next equal number of films. This procedure is repeated until it is impossible to obtain a processed strip equivalent to the standard, regardless of the time of development.

Consideration of the magnitude of the variations in films and developing solutions observed in Section B would indicate the

[9] Charles Weyl and S. Reid Warren, Jr., Apparatus and Technique for Roentgenography of the Chest, page 136, Charles C. Thomas, 1935. W. E. Chamberlin and R. R. Newell, Development of Roentgen Film: A Method of Determining the Potency of the Developer, Am. Jour. Roentgenol. and Rad. Ther., May, 1930, **23,** 549.

[10] If a densitometer is not available, densities may be measured approximately by visual comparison with a standard strip of measured densities which may be obtained from one of the manufacturers of x-ray film. It is extremely important in making such a visual comparison that the standard step and the unknown step be placed side by side with edges touching and that the light from every portion of the viewing box other than that illuminating the two steps be blocked off. Covering the viewing box by a 14 × 17 in. piece of cardboard with a rectangular hole just large enough for the two steps is a convenient method of providing the proper illumination.

advisability of testing these products at regular intervals. It is recommended that tests be performed every three months upon the films and developing solutions of the leading manufacturers. The results of the investigation described in Section A and Section B form the basis for the following recommended test procedure:

1. A can of prepared powders for making one gallon of developing solution should be obtained for each make of developer to be tested. One-half of the quantities in each can should be used to prepare one-half gallon of developing solution, according to the instructions of the particular manufacturer. The remaining half of the powders in one or more of the cans should be tightly sealed and kept in a cool place as a control for the next test three months later. The powders which have been held over from the preceding test in this manner should be used to prepare one-half gallon quantities of one or more makes of developer.
2. A roentgenographic exposure of the eight-step aluminum ladder described in Section A should be made on a piece of each make of film to be tested at the following technic:
   X-ray tube voltage, 80 kv.p.;
   Average x-ray tube current, 100 ma.;
   Time of exposure, $^1/_{10}$ second;
   Focal spot-film distance, 72 inches.
   It is absolutely imperative that these exposures be carefully and precisely controlled, that no change in the apparatus shall have occurred since the preceding test, and that the same pair of intensifying screens be used.
3. Strips approximately one-half inch in width should be cut from the middle six inches of each piece of exposed film in the manner described in Section A. A strip of each make of film should be developed in each developing solution, including the one or more solutions made with powders preserved from the preceding test. All strips should be developed for six minutes at a solution temperature of 65° F.
4. After the strips have been processed the densities should be measured and curves of density against thickness of aluminum like those shown in Figure 1 should be plotted for each strip. Density and contrast values should be obtained from these curves for $^3/_8$ inch, $^5/_8$ inch, and $^7/_8$ inch of aluminum for each film-developer combination.

Having obtained the necessary data concerning density and contrast, the analysis of these data may be made in a manner identical with that of Section B. The relative speeds of any two makes of film or developing solution may be expressed as the ratio of the densities obtained in the two cases, and the relative contrasts may be expressed in the same fashion. The values employed to determine either speed or contrast for a particular make of film should be the averages of the values obtained with this make of film developed in each of the brands of developing solution. In the same way the values for a particular make of developing solution are the averages taken over the various makes of film. The determination of changes in speed or contrast of any make of film may be made by comparing the data obtained from a strip of this film developed in a solution prepared with powders preserved from the preceding test and the data of the previous sample of this make of film which was developed in the solution prepared with the other half of the same powders during the preceding test. When the changes in speed and contrast for all makes of film under test have been determined the average speed or contrast change for all the films may be used in determining the speed or contrast change in any particular make of developer. Since the density or contrast values associated with a particular make of developer for the two tests are averages over all the films, the relationship between these two values is determined by the average film change and the developing solution change. When

the average film change is determined the change in the developer is easily computed. If more than one make of developer powders were preserved from the preceding test, this method of determining film and developer change may be repeated with the others to check the results obtained.

CONCLUSION

Modern technics for roentgen diagnosis require the highest possible degree of accuracy in the control of all mechanical, electrical, and photographic processes in order to obtain the maximum differentiation of shadows in the roentgenogram. Also, it is of extreme importance, particularly in connection with films of the chest, to have the highest possible standard of reproducibility. In the hands of the careful expert roentgenologist it has become possible to control the mechanical and electrical factors with reasonable precision. The application of careful experienced judgment will minimize the difficulties involved in the accurate calibration of the patient, and investigations being made of this problem give promise of the development of a precise scientific method of calibration. The photographic factor, unfortunately, is not so susceptible to accurate control by the roentgenologist.

Routine application of the recommended methods for the control of film processing and for testing films and developers will enable the roentgenologist to use the films and developers available to the best advantage. Unfortunately the existence of the marked variations which have been observed in the characteristics of these products precludes the maintenance of a truly high standard of reproducibility. With respect to these variations the roentgenologist has no control and must rely upon the manufacturer for assistance.

It would be extremely helpful to the roentgenologist if the manufacturers of films and developers were to:

(*a*) Maintain as strictly constant as possible all batches of films and developers which are sold as identical;

(*b*) Mark clearly, with a definite code number, any new or improved film or developer which differs in roentgenographic characteristics from its predecessors, or, include a sensitometric test strip in each package.

Roentgenologist are urged to make careful checks on films, developers, and processing methods in order to improve the constancy of their results.

The authors are convinced that the photographic materials and technics of roentgenography must be further standardized before any general improvement in optimum reproducible films can be introduced.

PHOTOGRAPHIC IMAGES OBTAINED IN TOTAL DARKNESS BY BOTH PENETRATION AND REFLECTION OF INFRA-RED RADIATION

By LEO C. MASSOPUST, *Milwaukee, Wisconsin*

Department of Anatomy, Marquette University School of Medicine

IN 1936 the author reported the results of observations on simultaneous infra-red roentgen photography (5). During the course of the experiments it was observed that: (*a*) there was definite evidence that the activating ray had properties of penetration, (*b*) a photographic image was obtained in total darkness, (*c*) a photograph and a radiograph were obtained simultaneously on the same infra-red plate.

The present report concerns, principally, the use of the infra-red photographic plate under various conditions to confirm and in part to make an attempt at clarifying these phenomena.

It is also hoped that with some necessary improvements in the experimental equipment and technic this method may develop to such an extent that it will be of some definite use in the field of radiology.

In introducing the observations under consideration, it might be well to mention a few of the characteristics of radiant heat, the infra-red ray.

The radiation from a luminous object is of a composite character; a portion consists of what we term *light*, but a far greater part consists of infra-red rays, which do not excite the optic nerve. Thus, our senses do not tell us much about the special properties of the different wave length regions of the infra-red.

When light and heat from a luminous source fall upon a mirror, it is found that the heat follows the same direction as the reflected light. Hence, the laws of reflection of radiant heat are the same as those for the reflection of light. Heat is refracted according to the same laws as light. In consequence of refraction, heat is concentrated like light at the focus of a convex lens. If radiant heat falls upon an unpolished surface it is scattered or diffused; reflection from it takes place at all angles and in all directions. The reflecting power of a substance is its property of throwing off a greater or less proportion of incident heat. Thus the relative reflecting power of polished brass is 100, while that of lamp-black is zero.

Beside thickness and color, the polish of a substance influences the transmission. Glass plates of the same size and thickness transmit more radiation as their surface is more polished. Bodies which transmit heat of any kind very readily, are not heated. Thus, a window pane is heated very little by the strongest heat from the sun.

Lamp-black absorbs the radiation from all sources in equal quantities, and very nearly completely. The behavior of polished metals is the reverse of that of lamp-black. They reflect the heat of different sources in the same degree. They are to heat what white bodies are to light.

A black body is one which completely absorbs all the radiation which falls upon it, being devoid of reflecting as of transmitting power. A lamp-black surface is practically a black body though not strictly so, for although it is perfectly black for visible radiations, it is not so for certain invisible radiations. When radiation falls on a black body the latter is heated, the energy of the incident radiation being transferred to the black body.

Materials, Methods, and Experimental Results.—In all of the experiments the Eastman infra-ray plate, type 1R, is used. The light-tight box shown in the diagram, Figure 1, is constructed of wood and lined with lead. The so-called filter which closes over the window in this box is a photographic film holder slide marked with four dots, and is safe to use with the ordinary

emulsions but is unsafe to use as protection for the infra-red plate. Obviously the loading of the box and development of the plates has to be done in total darkness. Various methods and applications of infra-red materials are discussed in previous publications. (1, 2, 3, 4, 5, and 6.)

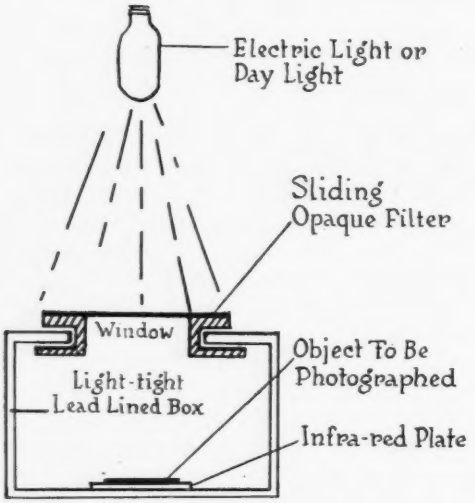


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Fig. 1. Light-tight lead-lined box.

All of the photographs shown in this report are contact prints made from the original negatives.

In Figure 2, strips of red and blue cellophane are pasted over one side of a card having printed matter on both sides. The card is photographed with reflected light. Hence, a definite image of the cellophane and printed matter on one side of the card is obtained.

In Figure 3, the card is illuminated with transmitted light. A photographic film is placed over the card in the same manner as if a print were being made from a negative. The image of the strips of cellophane are also recorded on this plate, together with the printed matter on both sides of the card.

In Figure 4 the same card, containing the strips of colored cellophane, is placed in contact with the emulsion side of an infra-red plate. The plate and card are placed in the light-tight lead-lined box (Fig. 1), with

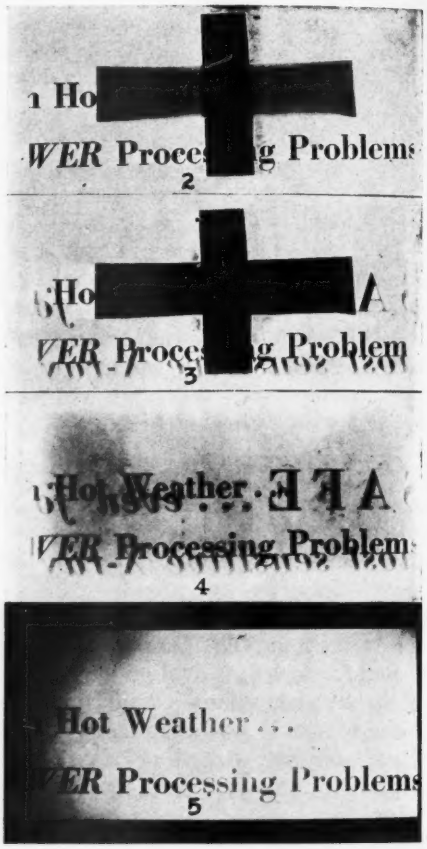

Fig. 2. Photograph of a white card having printed matter on both sides and strips of red and blue cellophane pasted over the printed matter. Illumination was from a 500-watt tungsten bulb for 3 seconds with diaphragm set at F. 22. Par speed portrait film. Contact print.

Fig. 3. The same card as used in Figure 2 was illuminated with transmitted light and a sensitized film placed in contact with the card. Exposure time, 2 seconds. Par speed portrait film. Contact print.

Fig. 4. The same card as used in Figure 2 was placed on an infra-red plate, and the plate with the card placed inside the light-tight, lead-lined box. The emulsion side of the plate was directed upward toward the window in the box. Illumination was from a 500-watt tungsten bulb for 5 seconds. Eastman infra-red plate, type 1R. Contact print.

Fig. 5. Same as Figure 4 except for the following changes: The card was placed on the bottom of the box, while the infra-red plate was turned over, thus the emulsion side of the plate was in contact with the card, and the back of the photographic plate was directed toward the window in the box. Exposure time, 1 second. Contact print.

the emulsion side of the plate directed upward toward the window in the box. Illumination from a 500-watt tungsten bulb is directed over the opaque filter in the window of the box for five seconds. It is to be noted that the image of the cellophane is not recorded on the plate, that the background surrounding the card is white, and that the printed matter on both sides of the card is recorded on the plate. Hence, Figure 4 definitely establishes the conclusion that an invisible ray has penetrated through the card.

In Figure 5 the same card is placed on the bottom, inside the light-tight box. An infra-red plate is then placed on the card with the emulsion side in contact with the card and colored cellophane. Thus, the glass side of the plate is directed upward toward the window in the box. In other words, the activating ray must pass through the back of the sensitized plate and then through the emulsion before reaching the card. The illumination is the same as is used in Figure 4, but the exposure time is only one second. It is to be observed that only the printed matter on that side of the card in contact with the emulsion is recorded on the plate, that there is no image of the cellophane visible, and that the background surrounding the card is black. In view of this result it is safe to assume that Figure 5 has much the appearance of a reflected image. It is also interesting to note that in Figure 5 the radiation passes through the thickness of the glass plate and the emulsion before reaching the card, and that the exposure time is one-fifth that of Figure 4. In view of the fact that this invisible ray must pass through the plate and the emulsion before reaching the card, why does not the emulsion react uniformly? Or does the activating ray in this case become active only after striking the card and reflecting back to the emulsion?

Figure 6 is an ordinary photograph of a piece of heavy paper with printed matter on both sides. The illumination is reflected light from a 500-watt tungsten bulb. A heavy layer of lamp-black is deposited on the paper by smoke from a flame, concealing all trace of the reading matter on the white card.

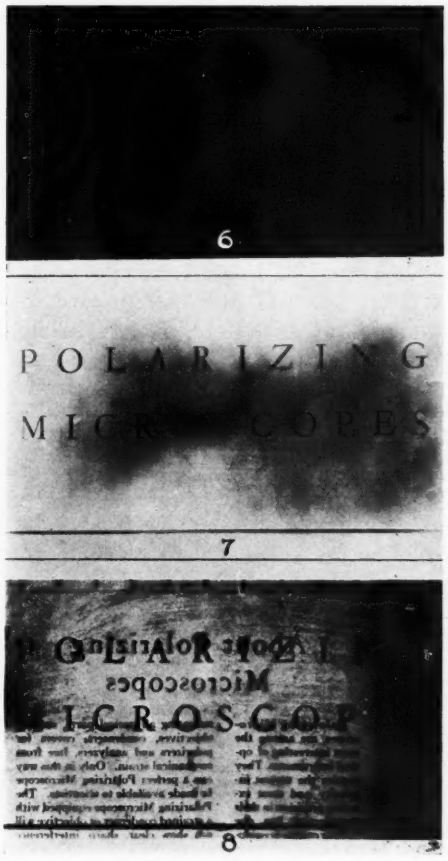

Fig. 6. The printed matter on one side of a card was concealed by a deposit of lamp-black from a flame. Reflected light from a 500-watt tungsten bulb was used for 5 seconds, diaphragm set F. 22. Par speed portrait film. Contact print.

Fig. 7. Same as Figure 6 except for the following changes: The infra-red plate in conjunction with the Wratten No. 25 filter was used and the exposure time was 2 minutes. Contact print.

Fig. 8. The same card was placed on the emulsion side of an infra-red plate and the plate with the card placed inside the light-tight, lead-lined box. The emulsion side of the plate was directed upward toward the window in the box. Illumination was from a 500-watt tungsten bulb for 20 seconds. Eastman infra-red plate, type 1R. Contact print.

Figure 7 is photographed under the same conditions as Figure 6 with this difference—an infra-red plate in conjunction with the Wratten No. 25 filter is used. The printed matter, obscured by the lamp-black, is

clearly visible. It is stated above that the relative reflecting power of lamp-black compared to polished brass is zero, and is said to absorb invisible radiations. Yet in Figure 7 a comparatively clear photograph of the printed matter which was entirely concealed by the lamp-black, is obtained.

In Figure 8 the card is placed on an infra-red plate inside the light-tight box. Again the printed matter on both sides of the card is recorded on the plate. This result indicates that this invisible ray has penetrated the lamp-black and the card.

An attempt was made to duplicate the photographic results obtained in the light-tight box with an intense source of heat, but after a prolonged exposure from a glowing hot-plate, no activation of the emulsion was noted. These results were duplicated with daylight, however, at a temperature of five degrees below zero, Fahrenheit. Due to the fact that the daylight was less intense than the light from the tungsten bulb, a longer exposure time was necessary.

SUMMARY

In analyzing the experimental evidence thus far presented the following conclusions seem to be justified:

1. The infra-red plate responds very readily to wave lengths selected from visible light by an opaque filter.

2. An invisible ray has the properties of producing a photographic image by both penetration and reflection.

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SOURCES OF ERROR IN RADIOLOGICAL INTERPRETATION IN TUMORS OF BONE[1]

By A. C. SINGLETON, M.D., *Toronto, Canada*

From the Departments of Radiology, University of Toronto and Toronto General Hospital

THE diagnosis of tumors of bone remains one of the most difficult problems confronting surgeons, radiologists, and pathologists, and this in spite of intensive study of the subject by large numbers of clinicians and research workers. The literature on every aspect of this problem is extensive, and great advances have been made in the diagnosis of these lesions. From the Bone Registry of the American College of Surgeons has come a workable classification of tumors of bone which has done much to bring order out of the chaos of confusing and clinically impractical terminology previously existing (Table I).

TABLE I.—CLASSIFICATION OF BONE REGISTRY

1. Metastatic tumors
2. Periosteal fibrosarcoma
3. Osteogenic tumors (benign and malignant)
4. Inflammatory conditions
5. Benign giant-cell tumor
6. Angioma (benign and malignant)
7. Ewing's tumor
8. Myeloma

Kolodny (1), in his masterly review of the material of the Bone Registry up to 1927, evolved a classification of primary malignant newgrowths of bone which is clear, concise, and very practical. His classification is as follows:

(*A*) Osteogenic sarcoma
(*B*) Ewing's sarcoma
(*C*) Myeloma
(*D*) Unclassified sarcoma

The groups are arranged in the order of frequency of the various types of primary bone neoplasms. Osteogenic sarcoma is by far the most common of malignant bone tumors, accounting for about 80 per cent of all cases. Ewing's sarcoma has been variously quoted as comprising from 7 to 15 per cent of cases, while myeloma is responsible for about 3 per cent of hemangioendotheliomas and angiosarcomas of bone, which Kolodny carries in the unclassified group, and rare tumors, as is also the periosteal fibrosarcoma.

There is no better illustration in the field of medicine of the need of close correlation of clinical and laboratory data than in the diagnosis of bone tumors. It is very hazardous to express an opinion on roentgenographs of bone lesions without having at least an accurate abstract of the clinical history, and any discrepancy between the two calls for a careful review of all the findings.

With regard to the roentgenographs themselves, no effort should be spared to obtain as good visualization of the tumor as possible. Films should be made in at least two directions if the lesion is in a long bone, and stereoscopic views if the lesion involves the trunk or skull. In these cases patients should be closely questioned as to the presence of symptoms in other parts of the body, and roentgenographs made of any area of which they complain. In certain cases it will be necessary to make films of the entire skeleton to show multiple primary lesions or the presence of metastases. In all cases of suspected primary malignant newgrowth of bone, chest films should be made to discover possible metastases, because of the fact that the chest is the commonest site of secondary involvement in malignant bone tumors.

The essential point in the radiological investigation of cases of suspected bone tumor is to determine whether the patient has or has not primary malignant disease of bone. This may well be approached by the following stages: First: Has the pa-

[1] Read at the Fourth Annual Convention of the American Academy of Orthopædic Surgeons, St. Louis, Mo., Jan. 13, 1936.

tient a tumor of bone? Second: Is the tumor benign or malignant? If malignant, is it primary or secondary?

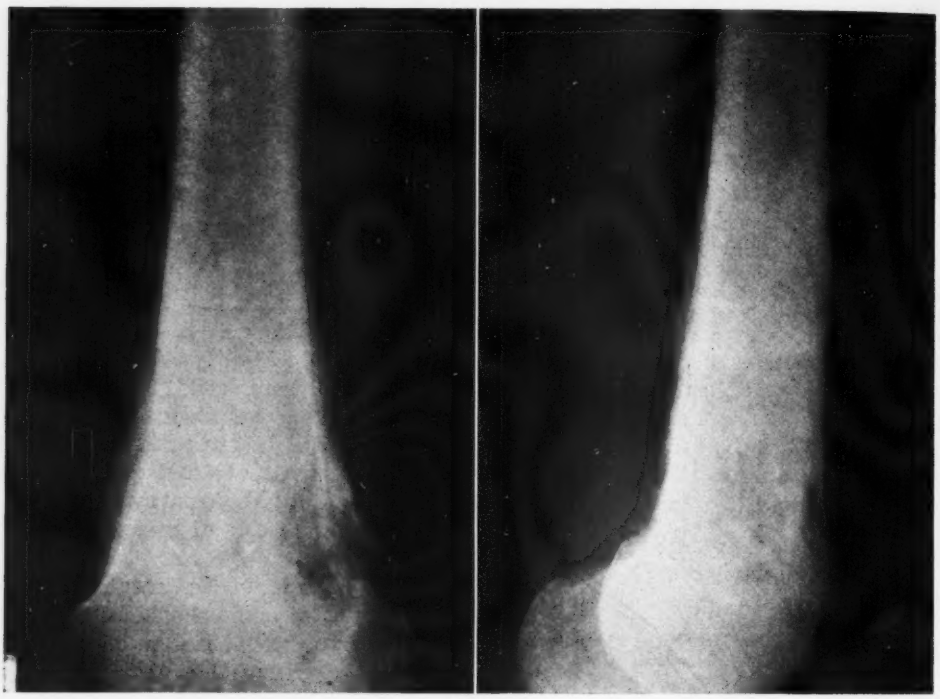

Fig. 1. Illustrates the difficulty, not infrequently experienced, in differentiating between osteogenic sarcoma and osteomyelitis. The smooth, subperiosteal new bone formation over the lower end of the femur led, in this case, to the erroneous diagnosis of osteomyelitis. Microscopically, this was osteogenic sarcoma.

The differential diagnosis involved in the answer to the first question is between inflammatory disease of bones and joints, and newgrowth. The radiological differentiation of these lesions is frequently most difficult, and this first step in the radiological investigation of malignant bone tumors is productive of a large proportion of the errors of their diagnosis. The varying degree of response of bone to various types of infections, and at varying stages of disease, produces the widest variation in the roentgenographic picture in osteomyelitis. The changes are limited to the bone itself, and there is no soft tissue extension. There is elevation of periosteum early in the disease with sub-periosteal bone formation parallel to the shaft. Sequestration of moderately large areas of bone is not infrequent, and there is an evenness of density throughout the area of involvement in chronic cases. Osteomyelitis enters the differential diagnosis of bone tumors in two ways—first, the differentiation of chronic osteomyelitis from the osteoblastic type of osteogenic sarcoma (Fig. 1), and second, the differentiation of early osteomyelitis from Ewing's sarcoma. In the latter case the similarity of the early clinical history in the two lesions may contribute toward confusion of diagnosis. In infective arthritis, the atrophy of bone close to the joint involved may simulate the irregular bone destruction of malignant tumor, and in the early stages of disease the differentiation of the two is not infrequently difficult, particularly in the spine, pelvis, and shoulder

joints, where it is not possible to obtain roentgenographs showing all portions of the periphery of the involved bone (Fig. 2).

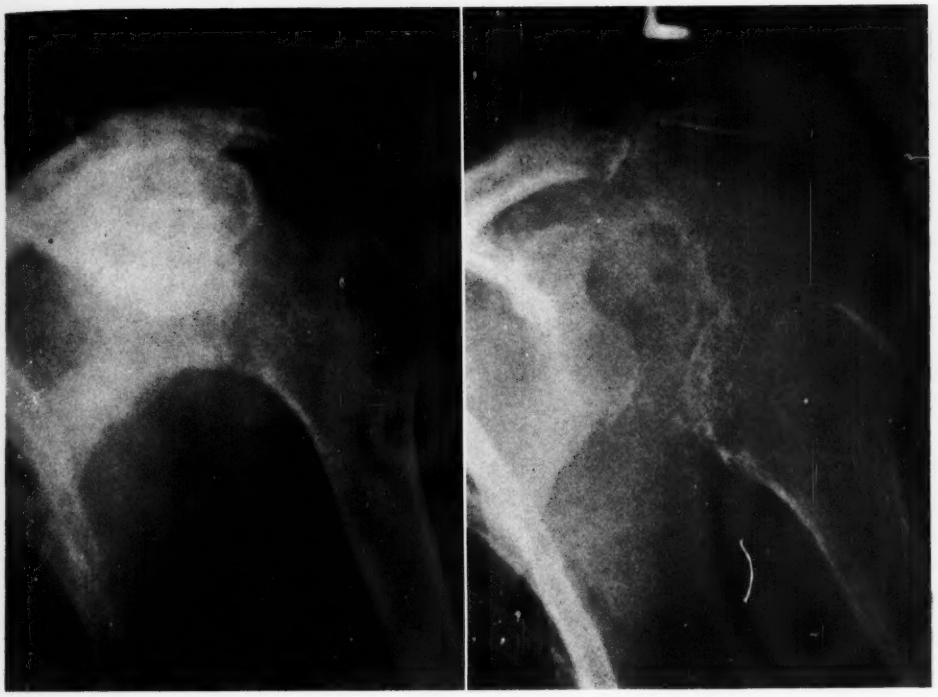

Fig. 2-*A*

Fig. 2-*B*

Fig. 2-*A*. Roentgenograph of shoulder shows mottled bone absorption in the neck of the scapula and in the head and neck of the left humerus, associated with decrease in joint spacing in the shoulder joint. These findings led to the opinion that this was an infective arthritis, probably tuberculous.

Fig. 2-*B*. Roentgenograph made of the same shoulder two months later shows an obvious tumor of the scapula. Microscopically, this was osteogenic sarcoma.

In our own group of primary malignant bone tumors, this confusion of inflammatory lesions with newgrowth was responsible for about 50 per cent of the erroneous radiological diagnoses.

The differential diagnosis of benign and malignant bone tumors is occasionally most difficult and sometimes impossible. Indeed, the pathologist with multiple microscopic sections of the tumor is occasionally unable to state whether or not the tumor is malignant, or if the slides be submitted to a number of pathologists, there will be disagreement on the fundamental question of the presence and degree of malignancy. Roentgenographs of typical benign bone tumors present fairly characteristic findings. As pointed out by Codman (2), they are either inside or outside the bone, but not both. In enchondroma and benign giant-cell tumor there is usually intact cortex over the tumor except at the site of pathologic fracture, and there is a sharp clean-cut line of demarcation between tumor and normal bone. In exostosis also the cortex is intact and continuous with cortex of the shaft of the bone and the tumor contains normal medulla. A destructive solution of continuity of cortex, on the other hand, is in favor of malignant tumor. An indefinitely outlined soft tissue mass associated with an osseous lesion is also in favor of malignant newgrowth of bone (Fig. 3).

The differential diagnosis of primary and secondary malignant disease of bone may be divided into the consideration of single

and multiple lesions. In solitary malignant newgrowth, the differential diagnosis will be among solitary secondary carcinoma and (*a*) osteogenic sarcoma, (*b*) Ewing's sarcoma, (*c*) extension of overlying soft tissue tumor to bone, (*d*) unclassified sarcoma of Kolodny's classification, (*e*) solitary myeloma. The age of the patient, the site of the lesion, the presence or absence of lung metastases, and the search for a primary extra-osteal newgrowth, will usually exclude carcinomatous or sarcomatous metastases, and extension of overlying tumor to bone. In multiple bone lesions the conditions most commonly to be differentiated are multiple myeloma and secondary carcinoma. Here the age incidence is the same for both lesions. The bones commonly affected are the same, namely, the axial skeleton, upper ends of femora, the humeri, and skull. Of these two lesions there is much greater tendency for carcinoma to destroy cortex of bone in an irregular manner, whereas myeloma tends to be more central and expansible. There is noted in many cases of myeloma, a tendency of the lesions to be rounded and uniform in size, particularly in the ribs, while secondary carcinomas are more likely to show wide variations of size and shape. The absence of chest metastases in the presence of multiple destructive bone lesions in a patient over forty should always suggest myeloma, particularly if no primary carcinoma can be found. The differentiation of primary and secondary newgrowth of bone in our own series of cases has been responsible for the smallest

Fig. 3. Illustrates the difficulty in certain cases of differentiating benign from malignant bone tumor. The irregular bone destruction in the neck of the femur, with solution of continuity of cortex and indefinite outline between tumor and normal bone, led to the radiological opinion of malignant tumor in this case. Surgically and microscopically, it was benign giant-cell tumor.

Fig. 4. This case illustrates the rather infrequent difficulty of differentiating between primary and secondary malignant newgrowth in bone. It was felt that this case presented the appearance of osteogenic sarcoma of the osteolytic type. It later proved to be metastatic fibrosarcoma from primary soft tissue sarcoma of the thigh.

number of errors in radiological interpretation. The thorough clinical and radiological search for a primary carcinoma in patients of cancer age with skeletal lesions has unquestionably contributed largely in this regard (Fig. 4).

By carefully following the above points, the fundamental question as to whether or not a given lesion is primary malignant newgrowth of bone, may be answered in the majority of cases. However, there will always be a certain percentage of actual errors in interpretation, and a number of cases in which diagnosis is uncertain.

Having arrived at the opinion that a given lesion is in all probability a primary malignant tumor of bone, one must try to place it in one of the four main groups of primary malignant bone neoplasms. The classical radiological findings of the more common primary malignant bone tumors have been discussed so frequently that they need be referred to only briefly at this time.

Osteogenic sarcoma, which has the widest age incidence of any of the malignant bone tumors, presents varying degrees of bone production and destruction, and may be divided into osteoblastic and osteolytic types, based on the preponderance of one or the other characteristic. The osteoblastic type, when well marked changes have developed, presents a roentgenographic appearance which is characteristic. The young patient, with involvement of the diaphyseal region of a long bone, showing a spindle-shaped elevation of the periosteum, periosteal spur formation, radiating spicules of new bone at right-angles to the shaft, an indefinitely outlined overlying soft tissue mass, limitation of the growth by epiphyseal line, and the presence of the shaft of the bone unexpanded and possibly fragmented showing through the tumor, presents a picture which, once seen, is never forgotten. In cases in which osteolytic changes predominate, the radiological findings are less characteristic. There is usually seen, however, a mottled appearance of less than normal bone density in the end of a long bone, the involvement not infrequently extending into the head of the bone if the epiphyseal line has fused. There is little or no expansion of the cortex, and actual destruction of cortex is a common finding. Pathologic fracture is not infrequent in this type of tumor. Osteogenic sarcoma is usually a solitary bone lesion although occasionally multiple tumors of this type are found. In such cases the question comes up as to whether they are true multiple primaries, or one primary with bone metastases.

Ewing's sarcoma in long bones usually presents the following findings: There will be a long area of involvement of the shaft, presenting increase in density of the medulla, elevation of the periosteum and formation of new bone in layers, giving the so-called "onion-skin appearance." Later in the course of the disease there will be areas of bone destruction within the lesion. Reference has already been made to the differential diagnosis of Ewing's sarcoma from early osteomyelitis. In our own group of cases the confusion of Ewing's sarcoma with osteogenic sarcoma has been a relatively frequent source of error. With regard to the therapeutic test of radiation, the response of our cases of Ewing's sarcoma has not been spectacular, and the response of osteogenic sarcoma has been so variable that we have found this test to be of little practical value in differentiating the two lesions.

Myeloma presumes the prefix, multiple, as only isolated cases of solitary lesions of this type have been reported. The multiplicity of bone lesions, the mature age of the patient, the characteristic sites of involvement, namely, ribs, spine, pelvis, clavicles, sternum, and skull, with frequently pathologic fractures of ribs or spine, and the absence of lung involvement, constitute the characteristic findings in this disease.

Periosteal fibrosarcoma produces pressure deformity on bone from without—but seldom, if ever, invades bone and does not essentially differ from fascial fibrosarcoma.

Angio-endothelioma and angiosarcoma

are so rare and the radiological findings of the reported cases so atypical that no characteristic radiological findings have yet been evolved for these tumors. They are usually diagnosed as osteogenic sarcoma.

DISCUSSION

With regard to the fundamental question of whether a given lesion is or is not a primary malignant tumor of bone, a careful study of the radiological evidence will lead to a division of cases into—

(*A*) Those lesions which are obviously malignant;
(*B*) Those which are almost certainly benign;
(*C*) Those in which there is doubt as to the benignity or malignancy of the lesion.

Careful correlation of the clinical and radiological data in these cases will allow of a correct diagnosis in a large percentage of bone tumors. There will remain, however, an appreciable group of cases in which one cannot arrive at a definite diagnosis and in which biopsy becomes imperative to obtain a basis for rational treatment.

The great question of the safety or advisability of doing biopsies in cases of bone tumors does not come within the province of the present discussion, but I do not believe that radiological investigation will obviate the necessity of microscopic examination of tissue, particularly in those cases in which radical surgical treatment is to be undertaken. Radiology has contributed very largely to the general knowledge of bone tumors and is of great value in their diagnosis. It must not be regarded, however, as supplanting other methods of investigation, but as an integral part of the scientific study of these cases. The careful correlation of clinical, radiological, and pathologic data is essential in arriving at the correct diagnosis as a basis for the evaluation of methods of treatment of tumors of bone.

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THE ROENTGENOLOGIC IMPORTANCE OF THE LEFT OBLIQUE POSITION IN CHOLECYSTOGRAPHY

By MAURICE FELDMAN, M.D., Assistant Professor of Gastro-enterology, *Baltimore, Md.*

From the Department of Gastro-enterology, University of Maryland

THE technical difficulty of obtaining satisfactory visualization of the gall bladder in all instances is the cause of much skepticism in clinicians' minds regarding the reliability of cholecystography. Their criticism of the test is justly correct because they have experienced instances of normal operative findings in cases diagnosed by the roentgenologist as pathologic. The purpose of this presentation is to illustrate that it is not, as a rule, the cholecystographic test that is at fault, but rather the procedure in which the examination is performed. Since most roentgenographic examinations are carried out by technicians in busy laboratories, one must expect a certain small percentage of failures due to technical errors. However, the technician often lacks the experience in knowledge of the technical difficulties which underlie the principle of shadow visualization. It is to be regretted, too, that the roentgenologist often lacks control of the case, especially in hospital routine, and information regarding the patient's reaction to the dye, vomiting, diarrhea, and dosage is rarely given much attention. The routine carried out in the roentgenologic laboratory is of the greatest importance because in most instances it is here that the cholecystographic test is poorly managed. The non-visualizing gall bladder and that overshadowed by the bowel are the types which usually afford the greatest difficulty in diagnosis. There can be no question of doubt that true non-filling of the gall bladder represents a pathologic state in the biliary tract. However, it must be emphasized that in order to obtain the roentgenographic shadow of the gall bladder, sufficient technical knowledge is essential, since the proper roentgen technic plays an important part in the portrayal of the cholecystogram. It has been shown, since the advent of cholecystography, that the gall bladder varies in position, and it also has been definitely established that it moves with respiratory excursions, the distance varying from one to three inches. Attention to the importance of obtaining views of the gall bladder in both inspiration and expiration must be pointed out, as it is often of considerable aid in the elimination of overlying shadows. Its importance is stressed (1) because its movement places the gall bladder in another position where it may be separated from overshadowing loops of colon; (2) by changing the position, gallstone shadow within the gall bladder will normally move with the vesicle, thus determining whether or not it is within or outside of it, and (3) at times the gall bladder is situated close to the spinal column and respiratory movements not infrequently separate them.

Shifting of the x-ray tube will not infrequently separate the gall-bladder shadow from the colon; in most instances, however, this maneuver fails to accomplish the desired results. The routine roentgen technic for cholecystography has been fully described on numerous occasions. Although the similarity of technics differs little in the various roentgen laboratories, yet it must be pointed out that there are certain roentgenologic features regarding this test that are not fully appreciated. During the past few years, I have noted a large number of cases the films of which have been brought to me for diagnosis, revealing a non-visible gall bladder on which surgical interference has been advised for suspected biliary pathology. It was observed that the

Fig. 1-*A* (*upper left*). Roentgenogram made in the prone position during the expiratory phase of respiration. Note the gall bladder, overshadowed by the ribs.
Fig. 1-*B* (*upper right*). Same case, made during inspiration, in which the gall bladder is shifted to a lower level below the ribs.
Fig. 2-*A* (*lower left*). Roentgenogram in prone position. A suspected double gall bladder is shown.
Fig. 2-*B* (*lower right*). The left oblique position of same cases illustrates the tip of the gall bladder turned upward, producing the double shadow noted in Figure 2-*A*.

roentgenograms showing the non-visible gall bladder were all made in the prone posture and all were of similar technic with unvarying position. It has been our

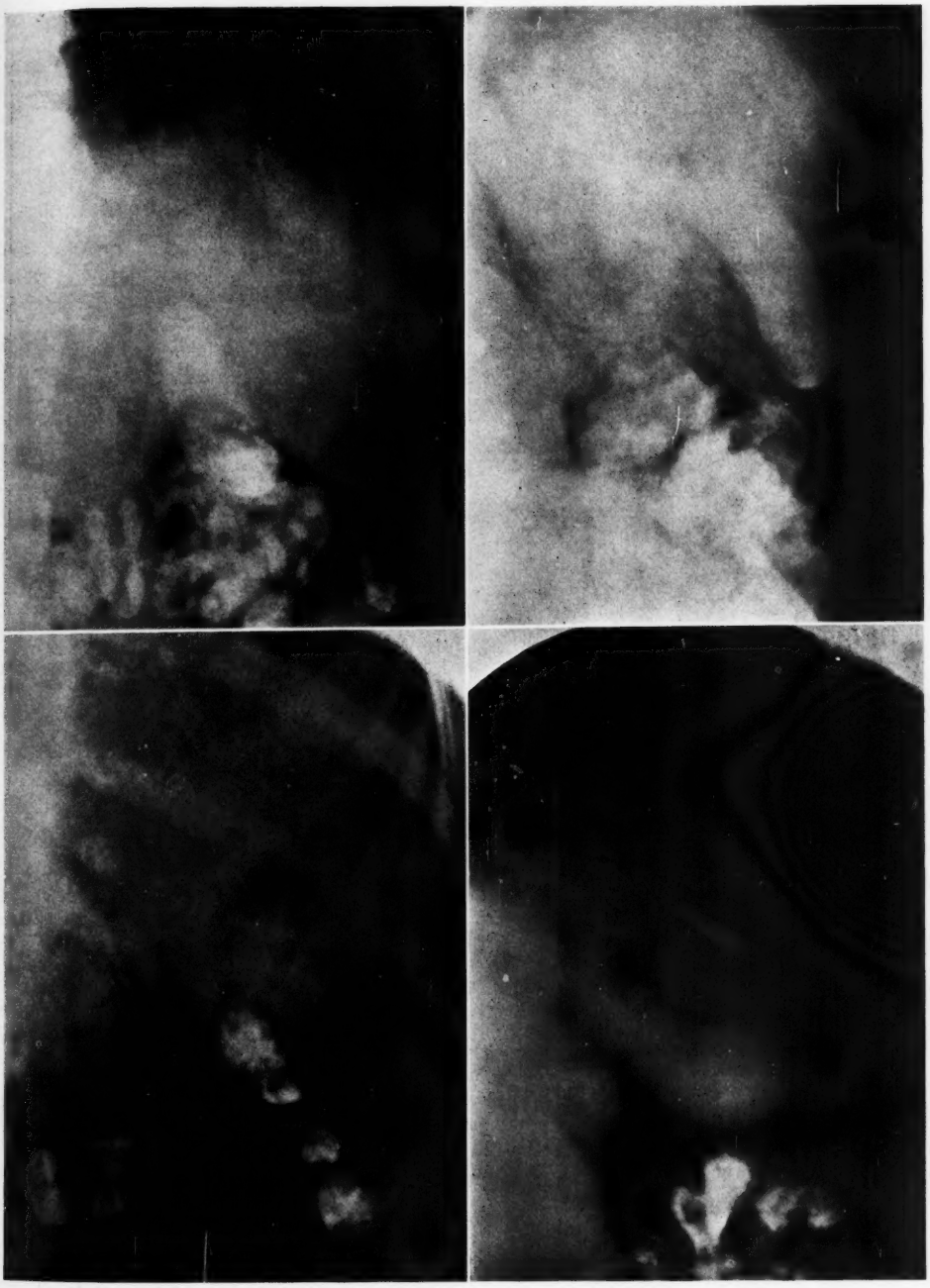

Fig. 3-*A* (*upper left*). The lower half of the gall bladder is overshadowed by the hepatic flexure.
Fig. 3-*B* (*upper right*). Same case, made in the left oblique position, reveals numerous small gallstones which could not be seen in the film, made in the prone position because of the overlying colon.
Fig. 4-*A* (*lower left*). Roentgenogram made in the prone position, showing the tip of the gall bladder overshadowed by the hepatic flexure.
Fig. 4-*B* (*lower right*). Gall bladder made in the oblique position. Note the greater increase in density of the shadow and its separation from the colon.

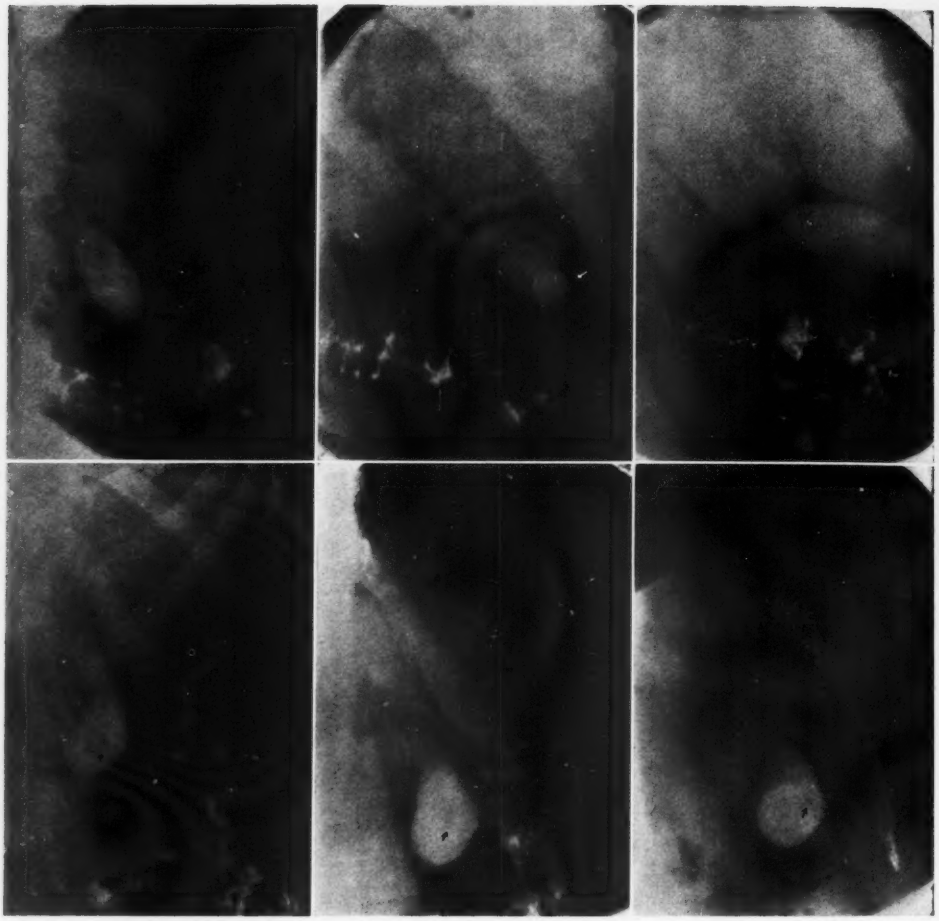

Fig. 5-*A* (*upper left*). Gall bladder in prone position, lying close to the spinal column. Note the extra shadow at its tip.

Fig. 5-*B* (*upper center*). Oblique view, showing a circular shadow at tip of gall bladder.

Fig. 5-*C* (*upper right*). Lateral view illustrates a constriction at the tip of the gall bladder (at arrow).

Fig. 6-*A* (*lower left*). Gall bladder in prone position, situated close to the spine. Note the small single negative shadow (at arrow).

Fig. 6-*B* (*lower center*). Same case, with abdomen rotated slightly to the left, showing the negative shadow still within the gall bladder.

Fig. 6-*C* (*lower right*). Roentgenogram made in the left oblique position. Note the small negative stone shadow at arrow, which has persistently shifted with the gall bladder. This case illustrates the importance of obtaining roentgenograms in different positions in order to eliminate overlying shadows.

custom not to rely upon such roentgenograms but to repeat the cholecystographic test. Upon careful investigation it was found that in many instances the gall bladder became visible by utilizing a special technic in this type of case.

In the routine roentgen examination of the gall bladder, films are made in the prone position, in both inspiratory and expiratory phases of respiration. All cases in which there is non-visualization, overshadowing of the bowel, poor shadows, or cases which require shifting of the gall bladder to eliminate undetermined shadows require further investigation. Besides taking the above roentgenograms,

Fig. 7-*A* (*left*). Gall-bladder shadow located close to the mid-line (at arrow). Note the overshadowing of the spine. This case was reported as one of non-filling, being overlooked on account of its position.
Fig. 7-*B* (*right*). Left oblique roentgenogram, illustrating the gall-bladder shadow, with a single medium-sized gallstone.

it is essential to obtain views in the left oblique or left lateral positions with the left side next to the table. Interestingly enough, we have observed that this position gives an immense amount of information and is of inestimable value in demonstrating a gall-bladder shadow which in many instances could not be obtained by any other procedure. The left oblique or left lateral view is also of considerable aid in obtaining a better and more clear-cut picture of the gall-bladder shadow, separating it from the colon and thus enabling one to visualize the vesicle to greater advantage. At times, slight rotation of the abdomen to either the right or left side helps in eliminating extra-gall-bladder shadows. A gall bladder overshadowed by the spinal column will often be overlooked, but when the roentgenogram is made in the left oblique or left lateral position the gall bladder is brought anteriorly and becomes clearly visible, enabling the roentgenologist to give an accurate report on the case instead of reporting a non-filling gall bladder. The greatest difficulty encountered by roentgenologists is overshadowing of the gall bladder by the hepatic flexure of the colon. The hepatic flexure not infrequently obliterates the vesicle shadow, which may at times be interpreted as a non-filling gall bladder. However, in most instances the gall bladder is only partly obscured by the colon. This type of case is also often misinterpreted, but by utilizing the left oblique or lateral view, errors of interpretation are minimized to a large extent.

SUMMARY

The greatest difficulty encountered by roentgenologists in the interpretation of

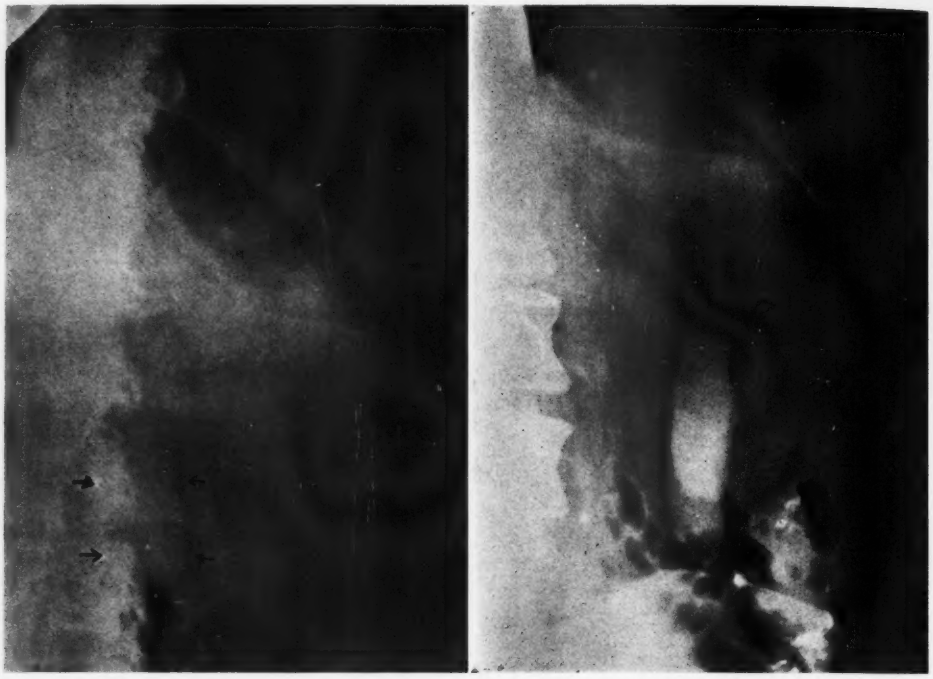

Fig. 8-*A* (*left*). Case reported as non-filling. Note shadow of the gall bladder close to the mid-line, overshadowed by the spinal column and psoas muscle.
Fig. 8-*B* (*right*). Left oblique position of same case clearly demonstrates a well-filled gall-bladder shadow. Organ functioned normally, revealing no evidence of stones, but a constriction is noted at its tip.

cholecystograms is the type of case in which there is non-visualization or in which the gall bladder is overshadowed by the hepatic flexure.

Stress is laid upon faulty roentgen technic as a cause of diagnostic errors.

Emphasis is laid on the importance of obtaining views of the gall bladder in different positions. The use of the left oblique or left lateral position affords the greatest aid in the portrayal of the gall bladder and in the elimination of extra-gall-bladder shadows. This procedure should be a routine measure in the cholecystographic study.

2425 Eutaw Place.

THE DEPENDENCE OF X-RAY ERYTHEMA ON WAVE LENGTH

By J. CRAMER HUDSON, PH.D., Collis P. Huntington Memorial Hospital, *Boston, Mass.*

THE roentgen as an x-ray dosage unit has been well established from a purely physical standpoint and is in general use throughout the world—at least for therapy work in which the radiation is generated at voltages up to two or three hundred kilovolts. It is generally, though not always, understood that this unit of dosage is based on purely physical principles; the physiologic effect produced by a roentgen of x-rays is not specified and must be determined experimentally.

Many radiologists feel that a knowledge of the erythema dose in roentgens is desirable and useful and the present paper presents a résumé of the results of such measurements taken on a number of therapy machines situated in the New England States. One object of these measurements was to determine whether or not the erythema dose as measured in roentgens depends upon wave length, a problem which has been investigated by numerous authors (1). In taking the various data recorded in this paper, the time of treatment for an erythema reaction on a particular machine was first secured from the roentgenologist in charge, and the total dose in roentgens determined from the product of treatment time in seconds and intensity in roentgens per second. In practically no case had the intensity from the machine been measured previously, the erythema time having been determined by trial only. All data as to machine settings, filter, treatment distance, and length of time of treatment were secured from the roentgenologist in charge and these same conditions were maintained for a particular series of measurements. In some instances the same machine was used under a number of different treatment conditions, and therefore a series of measurements was taken for each different setting of the machine.

In carrying out the measurements in a particular case, the roentgenologist in charge or a technician operated the machine under as nearly identical conditions as those of treatment as possible and the intensity in roentgens per second was determined by means of a secondary ionization chamber. All measurements were made in air. The effective wave length was also determined in each case.

METHOD OF MEASUREMENT

In carrying out the various intensity measurements, four portable ionization dosimeters have been used at various times. Occasionally, measurements were taken on the same machine with two different instruments but this was not generally the case as the different dosimeters were always calibrated against a standard air chamber and so would naturally agree among themselves. The standard air chamber used for the calibration of the secondary chambers is of the type first used by Duane (2) and is set up permanently for calibration purposes in the Collis P. Huntington Memorial Hospital, Boston.

Two of the dosimeters used in the measurements are Wulf Ionometers secured from Germany and recalibrated with the standard chamber. The calibrations received with the instruments for some reason did not agree with each other or with the standard chamber, but after being recalibrated they retained their calibrations quite satisfactorily, provided the rays entered the ionization chamber always from the same side. The chambers show a marked directional effect which may account in part at least for the poor agreement of their calibrations. They show also a small wave length effect and this must be taken into account, not only when making intensity measurements but also in determining the effective wave lengths.

The other two dosimeters are Victoreen instruments, one of them of the original type in which the ionization chamber is fixed permanently to the electrometer;

the other is of the more recent condenser type. Neither of these showed any directional effect or any wave length effect over the region in which it was used, *i.e.*, from about 0.4 Å. to 0.1 Å. effective wave length. The first of these two instruments had to be adjusted slightly to bring its calibration into agreement with the standard chamber, but the second one, secured within the past year, has agreed consistently with the standard air chamber to within 1 per cent.

In specifying the quality of the radiation the effective wave length as defined by Duane (3) was measured. This consists in finding the percentage of radiation which passes through a quarter-millimeter of copper and from a curve showing percentage transmission as a function of wave lengths, the effective wave lengths may be read off. The great advantage of specifying quality in this fashion is the fact that one needs only a single added observation to make the determination.

In all cases a number of readings of intensity were made, and the average value is recorded in the data. The spark gap voltage, as recorded in the data, is the value secured from the machine in question either with a point gap or with a sphere gap with spheres 10 cm. in diameter. Not too much reliance can be placed on these values, though they will give some indication of the approximate voltage on the roentgen-ray tube.

kv., and the radiation had an average effective wave length of about 0.4 Å. The letters in the extreme left-hand column designate the machine on which the measurements were made. The other data are self-explanatory. The first two data, *A1* and *A2*, are of some interest since these represent two different tubes, operated on the same machine with presumably exactly the same operating conditions, as far as could be determined from switchboard settings, current, filter, etc. The tube used in *A2* was a new tube with the glass quite clear, while that used in *A1* was an old tube with a quite noticeable black deposit on the glass. One would suppose that this black film was probably tungsten and acted as an added filter to cut down the intensity of radiation, as there was a difference of 33 per cent in intensity. However, the added filter apparently caused no appreciable change in the effective wave length. The data in these cases indicate how much variation may be present, particularly when one uses unfiltered radiation, even though all settings as far as can be determined are the same.

The most interesting feature of Table I is the remarkable consistency in the number of roentgens necessary for any erythema. The mean value is 326 r, and no single value deviates from this by more than 6 per cent. It must be borne in mind too that most of these machines are not in the larger cities and so represent essentially

TABLE I.—UNFILTERED RADIATION

Machine	Spark Gap Voltage	Ma.	Filter	Focus-skin Distance	Intensity, r/sec.	Time of Treatment	Total, r	λ Eff. Å.
A1	109	8	None	30 cm.	3.34	100 sec.	335	0.41
A2	109	8	None	30 cm.	4.50	75 sec.	338	0.42
B	120	5	None	30 cm.	3.27	100 sec.	327	0.43
C	100	4	None	30 cm.	1.49	3.75 min.	335	0.44
D	106	5	None	20 cm.	4.92	70 sec.	344	0.41
E	100	3	None	20 cm.	2.33	2.25 min.	315	0.42
F	100	4.5	None	30 cm.	1.03	5 min.	309	0.43
G	100	4.5	None	30 cm.	2.12	2.5 min.	318	0.42
H	100	4	None	30 cm.	1.50	3.5 min.	315	0.41
				Average			326	0.42

The data are given in the accompanying tables, that for unfiltered radiation being in Table I. It is evident that most of these machines were being operated at about 100

independent experimentation to determine the erythema time.

One other feature is worthy of comment, and that is the wide divergence in the

number of milliampere-minutes necessary to produce an erythema. It is obvious that milliampere-minutes as an indication of dose is of little meaning in the case of unfiltered radiation.

same voltage and his value is, therefore, not strictly comparable to the value 325 r as found here.

In Figure 1 is plotted Curve *A* showing erythema dose in roentgens (measured in

TABLE II.—FILTERED RADIATION

Machine	Spark Gap Voltage	Ma.	Filter	Focus-skin Distance	Intensity, r/sec.	Time of Treatment	Total, r	λ Eff. Å.
C	145	4	4 mm. Al	30 cm.	0.414	21.5 min.	532	0.26
D	135	5	4 mm. Al	20 cm.	0.906	8 min.	435	0.28
E	135	5	3 mm. Al	25 cm.	0.950	8 min.	456	0.29
I	150	4	3 mm. Al	30 cm.	0.744	11.25 min.	501	0.27
				Average			480	.28
A2	140	6	0.25 mm. Cu	30 cm.	0.440	20 min.	530	0.22
C	145	4	6 mm. Al	30 cm.	0.343	27.5 min.	570	0.23
I	150	4	0.25 mm. Cu 1 mm. Al	30 cm.	0.346	29 min.	600	0.21
J	120	15	0.25 mm. Cu 1 mm. Al	50 cm.	0.300	32 min.	575	0.22
				Average			570	.22
I	165	4	0.5 mm. Cu 1 mm. Al	30 cm.	0.242	50 min.	726	0.18
J	202	30	0.5 mm. Cu 1 mm. Al	50 cm.	0.912	13 min.	710	0.16
K	200	20	0.5 mm. Cu	50 cm.	0.667	17 min.	680	0.17
L	200	20	0.5 mm. Cu	50 cm.	1.00	11.5 min.	690	0.17
				Average			700	0.17

The remainder of the observations have been placed in Table II and it is evident that all the data may be divided into three groups: having effective wave lengths, measured by means of 0.25 mm. Cu, of 0.27 Å., 0.22 Å., and 0.17 Å.; and the erythema doses are 480, 570, and 700 roentgens, respectively. More variation is found, not only in the conditions operation but also in the number of roentgens necessary for an erythema. In all cases it is assumed that the radiation is all given at one sitting. This does not represent the usual practice in the case of 200 kv. radiation, however, and for this radiation, in practically all instances, 800 or 900 r are given over a period of four or six days. It is interesting to note that Thoraeus (4) reports that in Sweden generally the erythema doses measured in air for approximately the same type of radiation are 450, 550, and 700 r as compared to 480, 570, and 700 r from the present data. He gives also 400 r as the erythema dose for 100 kv. radiation filtered through 1 mm. Al. This radiation is somewhat harder than unfiltered radiation at the

air) as a function of effective wave length. The points are the actual observations as taken from Table II, while the crosses represent the mean values of the dose for the

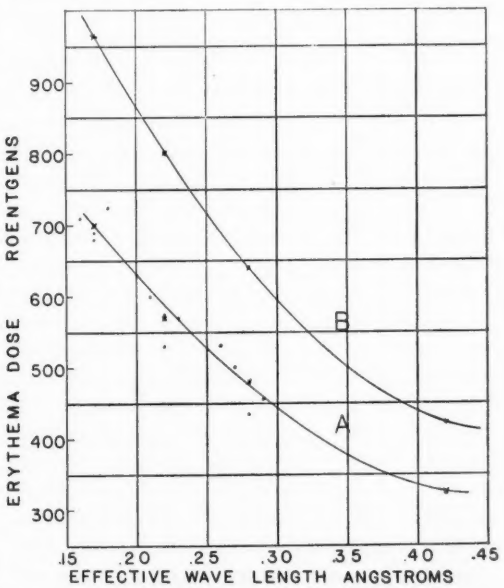

Fig. 1. The erythema dose in roentgens for various effective wave lengths.

mean effective wave lengths as determined from the three groups of the same table and also the mean value from Table I. These measurements were made in air without back-scatter. One may estimate the back-scatter for various wave lengths and sizes of field (4), and if this is done for a field of 10 × 10 cm., one secures the Curve *B*, Figure 1. It is evident that under actual conditions of treatment the number of roentgens necessary for an erythema dose depends on the wave length of the radiation.

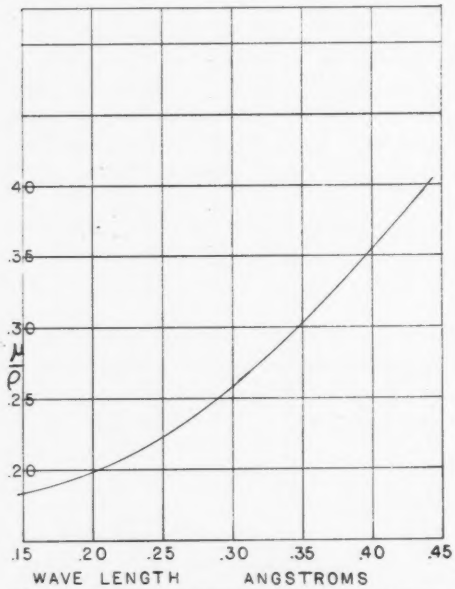

Fig. 2. The mass absorption coefficient of water for various wave lengths.

The absorption coefficient for tissue is practically that for water (5), the curve for which is shown in Figure 2, where mass absorption coefficient is plotted as ordinate and wave length as abscissa. Now one may calculate the amount of absorption by 1 mm. thickness of tissue for each of the four mean effective wave lengths as given in the tables. Bearing in mind that the doses for a 10 × 10 cm. field are 965 r, 800 r, 640 r, and 425 r for effective wave lengths 0.17 Å., 0.22 Å., 0.27 Å., and 0.42 Å., respectively, one finds that the amounts absorbed in the first millimeter of skin are 18, 17, 16, and 16 r for the corresponding wave lengths. Such a calculation assumes the energy per roentgen incident on the skin is a constant over this wave length region, and also that there is no marked change in wave length of the scattered radiation. Both of these assumptions are approximately true for this limited region of wave lengths. These calculations indicate that, while the variation of erythema dose is more than twofold over this region, the *total energy* absorbed in the superficial layers of skin is practically constant. The *percentage* absorbed in surface layers is not the same for the various wave lengths, of course, and so one uses the shorter wave length radiation for deeper lying tumors.

SUMMARY

Experimental data are presented showing the variation of erythema dose in roentgens with effective wave length over the region from 200 kv., 0.5 mm. copper filter, to 100 kv. unfiltered radiation. Calculations indicate that the difference in dose necessary for an erythema at the various wave lengths is due chiefly to the difference in absorption by the tissue.

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X-RAY THERAPY IN AMENORRHEA

By ASA B. FRIEDMAN, M.D.,[1] *and* BERNARD SELIGMAN, M.D.,[2] *New York City*

FUNCTIONAL disturbances of menstruation may often occur in women who have other evidences of glandular dyscrasias. Such secondary amenorrhea may or may not be associated with tumors of ovary, suprarenal or pituitary glands. When such tumors do exist there usually are more definite characteristic signs, such as defeminization or pituitary pressure symptoms. However, secondary amenorrhea often occurs without any definite evidence of tumor. It is further interesting to note that the symptoms of the climacteric are seldom present in functional amenorrhea.

The therapy of functional amenorrhea is, after the exclusion of local pathology such as tumor or pelvic inflammatory disease or other general debilitating conditions, either with ovarian and pituitary or thyroid substitution therapy, or by radiation therapy.

Mussey and Haines have reported 27 patients, between the ages of 16 and 29, with low basal metabolism rates and amenorrhea lasting from two to four years. The condition of 13 of these patients was benefited by glandular therapy. The longest duration of amenorrhea in any patient who responded to treatment was one year. The general health in 20 of these 27 patients was improved coincidentally with the elevation of the basal metabolic rate.

Treatment with female sex hormone has been reported by Zondak, Kaufman, Loeser, Dunn, and others. This form of therapy requires repeated intramuscular injections of large quantities of the hormones to establish and maintain the menstrual cycle. Menstruation has been induced and maintained with this form of hormonal substitution in many cases, in one patient even after a nine-year amenorrhea. The treatment, however, requires enormous quantities of progynon B, is costly, painful, and time-consuming to the patient and physician.

Radiation therapy has been used in the treatment of functional amenorrhea with excellent results. Van de Velde, with the administration of small doses of the roentgen ray to the ovaries, successfully re-established the menstrual cycle. Werner and Ligner found that hypophyseal stimulation with the x-ray produced similar results. Since then Opitz, Frankel, Flateau, Thaler, Doderlein, Hirsch, Rubin, Rongy, Kaplan, Drips, Ford, and others have reported cases of amenorrhea and sterility in which good results have been obtained by x-ray therapy. Yet despite these favorable results, x-ray therapy for the treatment of functional amenorrhea has not received the recommendation it deserves.

Radiation therapy in functional amenorrhea is used on the premise that we are dealing with either an alteration in function of the pituitary gland or with ovarian dysfunction.

In 1915 Van de Velde, in discussing radiation in gynecology, reported the resumption of menstrual function following small doses of x-ray applied to the ovaries. In 1920, Monn reported eight cases similarly treated. In 1922, Thaler reported a series of 147. In 1926, I. C. Rubin reported 12, while in 1928 Kaplan reported 35 cases so treated—all by ovarian radiation alone. In 1931 Kaplan first mentioned the use of ovarian and pituitary radiation and in 1933 Edeikin reported 56 cases with 40 successes. The majority had both ovarian and pituitary irradiation, but in one case only the pituitary region was treated. Most of these writers believe that radiation of the ovaries, with dosage too small to cause castration but large enough to be stimulative, offers no danger to the normality or health of the future offspring.

[1] Visiting Radiation Therapist, K.C.H., Div. of Cancer, Department of Hospitals; Ira I. Kaplan, M.D., Director.

[2] Associate Visiting Physician, K.C.H., Metabolic Clinic; H. Feinblatt, M.D.

Small doses of x-ray irradiation did not produce any microscopically discernible degenerative changes in the ovaries of animals. Wagner and Schoenoff gave a patient 5 to 10 per cent S.E.D. to one ovary and carefully protected the other ovary. At operation, within two weeks following irradiation, specimens of both ovaries were obtained. The histologic picture in the irradiated ovary was exactly like that of the control ovary: no evidence of degenerative effects was found. Kaplan states definitely that small does of x-ray, when properly administered, will not produce ill effects upon either the patient or the offspring. However, the question of the deleterious effect of x-ray dosage on the ovary (or testes), even when the dosage is too small to cause castration, is still a moot problem. Experimentally we know that the litter of irradiated mice or the succeeding generations of irradiated seedlings differ both in quantity and quality from those of controls even when the dosages used were very small. It is, therefore, not entirely logical to conclude that, because the immediate offspring of an x-ray-stimulated ovary is grossly normal, that the hereditary characteristics of the offspring have not been altered. Obviously it would require careful observation of many succeeding generations of the irradiated ovum to prove this point. Several generations of animals have been watched and alteration and hereditary characteristics have been demonstrated. It seems, therefore, in those cases in which pituitary radiation alone is adequate, we can avoid the problem of influencing heredity. It may be wrong to over-emphasize this point, because, as stated above, so many good workers deny any untoward influence.

The dosage we have used in the treatment of the pituitary region is approximately as follows: 200 to 250 r units at the sella turcica. The factors were: 200 kv., 0.5 mm. Cu plus 1.0 Al, 40 cm. F.S.D., 200 r units to each of two lateral fields and one anterior field. The dosage used in the ovarian irradiation was kept below 100 r at the ovaries and administered through three or four pelvic fields, usually two anterior and two posterior pelvic ports.

Regardless of the mode of action, evidence is fast accumulating that x-ray therapy to the pituitary gland and/or ovaries causes a return of the normal menstrual cycle. In some individuals the menses are re-established for a period of time and a second course of irradiation has to be given.

CASE REPORTS

Nine consecutive cases of favorable responses are presented for consideration.

Case 1. K. C., aged 28 years, housewife, admitted Jan. 15, 1935, weight 210 pounds, height 64 inches, pulse 60, blood pressure 122/74, basal metabolic rate plus 6 per cent, urine negative, Wassermann negative. X-ray examination of the sella turcica showed calcification of the petroclinoid ligaments. Menstruation had always been irregular, occurring every two to three months and for one year she had had no periods. Menses were scant in amount, lasting two days. She had had two miscarriages, one in 1930 at six and one-half months and another in 1932 at four and one-half months. During the past five years she had gained 80 pounds and for three years had noted an increased growth of hair on the face, abdomen, and extremities. The diagnosis was a functional basophilism. She was given sex hormone therapy for eight months and menstruated Jan. 17, 1935, and in March, 1935. On Sept. 24, 1935, a course of x-ray therapy to the pituitary was given. She has menstruated regularly ever since and had a miscarriage at three months on Jan. 8, 1936.

Case 2. A. G., aged 23 years, seen in the clinic May 22, 1934, weight 222 pounds, height 61 inches, blood pressure 132/90, basal metabolic rate, plus 7 per cent. Her mother is a diabetic. She complained of amenorrhea of one year's duration and of increased obesity of 23 pounds in 10 months. Her menses had begun at 13, with a 30- to 32-day interval, and a flow for three days. They had been regular be-

fore the birth of a baby three and one-half years previously, but since then had occurred every two to four months. She had noted an increased growth of hair on the upper lip, chin, and chest for the past two years. She complained of headaches at the top of the head. Her ankles are thin, her hands short and broad. She has thin eyebrows and considerable fine hair on the face. Pelvic examination was negative. X-ray examination of the sella turcica revealed a small calcific deposit superior to the anterior clinoid process. She received theelin 50 r units weekly for three months without effect. On Aug. 27, 1934, her ovaries were irradiated and for two years since then she has menstruated regularly every 26 to 28 days, flowing normally two to three days. She has had two miscarriages during this period, both at five months.

Case 3. S. R., aged 21 years, single, admitted to the clinic in 1933, complaining of obesity, hirsuitism, and irregular menses. She began to menstruate at 13, menstruated regularly for two months, and then had intervals of amenorrhea of from 12 to 16 months between periods; at times the intervals were from four to five months. For the past six years she has had excessive hair on the face and body. She was treated with electrolysis but the hirsuitism of the face recurred. She has always been overweight. Under clinic care and a reducing régime, she lost 30 pounds in one year. Theelin, antuitrin, and pituitary extracts had no effect on her menstruation. She has aberrant sexual impulses. Height 63 inches, weight 185 pounds. Blood pressure 106/80, basal metabolic rate plus 5 per cent. X-ray examination of the sella turcica is negative. Patient has shortening of the metacarpal bones as compared with the bones of the fingers. She is emotionally unstable and has had occasional palpitation. On Jan. 15, 1934, x-ray treatments were started, 250 r to the pelvic and pituitary fields. She has been under observation for 30 months and has menstruated regularly. The diagnosis was functional basophilism.

Case 4. C. R., aged 33 years, married, entered the clinic Jan. 22, 1935, complaining of an amenorrhea for one year. She had scanty menses for eight years, every two or three months. She has had a marked gain of weight in the past year and moderate vertical headaches. She has two children, aged 9 and 4. Her weight is 174 pounds; height 64 inches; basal metabolic rate plus 7 per cent; blood pressure 119/76. X-ray examination of sella turcica negative. Moderate myopia; genitalia negative. Beginning April 10, 1935, x-ray therapy was administered to the pituitary and pelvic fields. Following treatment patient menstruated regularly every 23 to 28 days. The diagnosis was secondary hypogonadism.

Case 5. D. R., aged 23 years, married, admitted April 14, 1934, complaining of irregular menstruation since the onset of her menses, three days every seven to nine months. She had typhus at eight years; had been married twice, the first time for three years and had a child of five. The second marriage has lasted four years. She has a slight yellowish leukorrhea and is constipated. She stopped growing at 18. She had a slight growth of hair on her face and chest and stated that her feet have grown larger in the past two years. She has gained 13 pounds in one year. Her weight is 153 pounds; height $61\frac{1}{2}$ inches; blood pressure 110/80; basal metabolic rate plus 6 per cent; full face, large breasts, obese abdomen and hips, slight nucal pad. X-ray examination of fingers shows partial gigantism; x-ray examination of the sella is negative. She menstruated last in August, 1933. She was given theelin 50 to 100 U.R. every week and small doses of thyroid for six months without result. On Oct. 10, 1934, x-ray therapy to the pelvic and pituitary fields was started. Beginning Oct. 25, 1934, she menstruated for four full days. The bleeding was more profuse than ever before and she menstruated regularly until she became pregnant, giving birth to a normal female child in December, 1935, her first pregnancy in seven

years. She was nursing the infant when last reported.

Case 6. L. R., aged 32 years, married, was admitted in 1934, complaining of amenorrhea for 17 years, frigidity and sterility. She had a gradual gain in weight in 10 years from 150 to 262 pounds. She complained of anorexia, crying, moaning, bad dreams, and frontal headaches. She menstruated at 14 for three days. She had poliomyelitis as a child; an appendectomy five years ago; pneumonia two years before, and influenza one year previously. As a child she had nine operations on her legs for productive osteomyelitis. She had a slight hypertrichosis of the breasts, chin, and extremities. The mammæ were small; there was a marked girdle obesity. The posterior clinoid processes were anteriorly deviated. Weight 262 pounds; height 5 feet 10 inches; blood pressure 152/100; basal metabolic rate plus 16 per cent. The clitoris was twice the normal size; the cervix was small. Blood calcium 9.5; phosphorus, 2.5; blood sugar 160 mgm. per 100 c.c. In October, 1934, she was given a course of four treatments to the pelvic and pituitary fields. Her menses were re-established for a period of 22 months. She has not menstruated for the past two months and is now in the hospital under observation for abdominal pains.

Case 7. E. T., aged 18 years, single, entered the clinic in April, 1934, complaining of obesity, hypertrichosis, and amenorrhea of eight or nine months' duration. She had begun to menstruate at 14 years. She had always been fat, but as she grew older she grew stouter. Since the age of 16 she had noticed growth of hair on her face and abdomen. She had dyspnea, fatigue, and headache with eye strain. Weight 236 pounds; blood pressure 164/114; basal metabolic rate minus 9 per cent; glucose tolerance, normal; girdle type of obesity; small breasts; large clitoris. She was always irregular in her menses, and went from three to ten months without a period. In March, 1934, she received irradiation of the pelvic and pituitary fields. She menstruated normally until Nov. 16, 1935, and has not been seen since. Diagnosis is functional basophilism.

Case 8. R. W., aged 25 years, married, entered the clinic in November, 1935, complaining of irregular menses, loss of libido, and hair on face, chest, and arms for two and one-half years. She had begun to menstruate at the age of 14, with periods of from five to six days; very irregular; increasing amenorrhea had lasted from two to six months. She had been married for five years and was sterile. About two years before she had begun to develop hair on the chin and chest which had grown progressively worse in the past few months. She suffered severe frontal headaches, localized between the eyes. She had gained 50 pounds in the past few years without any increase in food intake. She tired easily and had palpitation on exertion. She stood cold weather well. She had been taking organic therapy without any result. Was of a short, stocky type, alert mentally, large square head, thyroid slightly enlarged, smooth and symmetrical, normal visual fields, teeth well spaced; lineal stria on abdomen, skin thick and dry; blood pressure 88/60. On Nov. 11, 1935, a course of four treatments to the pituitary fields were started. In January, 1936, she had a second course of treatments because of her persistent amenorrhea; she has menstruated normally since.

Case 9. G. H., aged 21 years, admitted Aug. 5, 1930, complaining of amenorrhea, sterility, and gain in weight. Her menses had begun at the age of sixteen and one-half years, occurred only twice a year, but flowed moderately for eight or nine days when they did occur. Dilatation and curettage were done a year previously by her family physician. This was followed by one period. She was fairly obese; weight gain was rapid and sudden at the age of 19; married two years but never pregnant; basal metabolic rate was low normal. Lipiodol injection of uterus and tubes showed no abnormalities. X-ray therapy to ovaries alone was given between Aug. 6, 1930, and Sept. 11, 1930. Menstruation was re-established one

month later and continued regularly until a normal pregnancy a year thereafter. Diagnosis was hypo-ovarianism.

CONCLUSIONS

Nine consecutive cases of amenorrhea due to endocrinopathies were treated with small dosage of irradiation and in all regular menstruation was re-established. The treatment given is simple, harmless, and inexpensive. The endocrinologic stigmata other than the amenorrhea were not influenced by the treatment.

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THE VALUE OF THE PRELIMINARY FILM WITHOUT OPAQUE MEDIA IN THE DIAGNOSIS OF ABDOMINAL CONDITIONS

By JAMES F. KELLY, M.D., F.A.C.R., Professor of Radiology, and D. H. DOWELL, B.S., M.D., Assistant in Radiology, Creighton University School of Medicine, *Omaha, Nebraska*

THE practice of medicine cannot be successful and progressive if one is forced to blindly follow routine procedures and fixed clinical laws. Nevertheless, when one considers the x-ray examination of the abdomen and pelvis and their contents, he is inclined to become dogmatic and insist on a clinical law which would require a preliminary film of any area containing an organ or system which later may be changed in appearance by the use of some special preparation for x-ray demonstration. At the present time, due to the progress made in the use of special methods of demonstrating certain structures, there has been a swing away from the use of films of the unprepared[1] abdomen and pelvis. Very often the only method of examination the clinician seems to care about is one in which some special preparation is necessary, and usually he orders the examination along these lines. Unfortunately this plan is very often followed by the radiologist, and in the special preparation important shadows such as opaque gallstones are obliterated, and the examination is worse than useless; it is misleading. There should be a clinical law requiring that preliminary films be taken of any organ or area in which any contrast method of examination is to be employed, as often a preliminary film of the area would bring out shadows of great diagnostic value which are later obscured by the use of any contrast medium.

The value or the necessity of a routine preliminary film of the abdomen of the unprepared patient in the biliary, gastro-intestinal, or genito-urinary x-ray examination will be evident as one becomes more experienced in the x-ray examination of the structures contained in these systems. This preliminary film would still be necessary even if the clinician were always able to distinguish between the patient with gall-bladder trouble and the one having a gastro-intestinal lesion, or the one having a gastro-intestinal lesion and the one having some pathology in the urologic tract, but such is not the case. Often, after the most careful history and physical examination, he is still in doubt as to which system is involved. The problem of the acute abdomen is also a hazardous one for the surgeon, internist, general practitioner, radiologist, and occasionally for even some of the other specialties, particularly the urologist, and less frequently the gynecologist and obstetrician.

Speaking technically, there are two types of examinations employed for the unprepared abdomen and pelvis, first the fluoroscope, second the use of the film, or these methods may be combined. Both methods have their indications and contra-indications, advantages and disadvantages. In the main, the density of the solid soft tissues of the kidney and psoas muscle of the unprepared abdomen may be taken as a standard density because they are of fairly uniform density which we designate as "normal density."

Gas in the tissues, as commonly found in the intestinal tract, casts a shadow somewhat darker than the surrounding more solid soft parts; in other words, it is less dense than normal density, and these shadows will be termed "minus density" (Fig. 1). In certain situations minus density shadows are of great diagnostic significance. On the other hand, numerous pathologic conditions obstruct the rays to a greater extent than the normal solid soft parts, and these areas are of greater density and are referred to as "plus density." In this latter group fall gallstones contain-

[1] *Unprepared* refers to those patients in whom special aid is not employed to bring out tissue differentiation. *Prepared* refers to those patients in whom some special preparation, such as the use of contrast media as barium, gas injection, lipiodol, thorotrast, etc., is used.

Fig. 1.

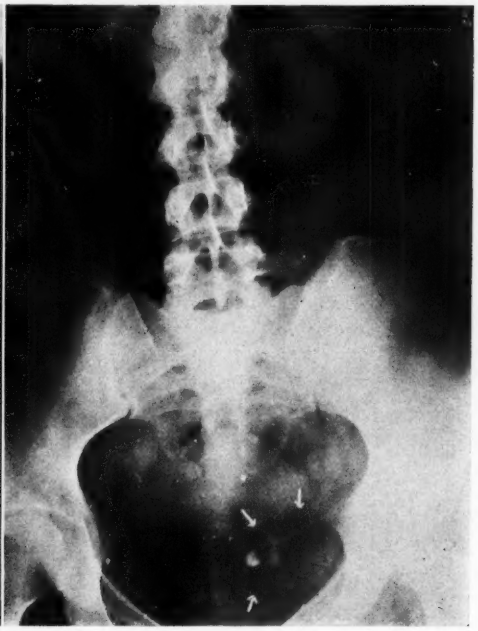

Fig. 2.

Fig. 1. In this film of the abdominal and pelvic areas we have all three densities illustrated. Areas I, III, and IV show normal soft tissue density; Area V, over the sacrum, shows increased or plus density; Area VI, over a collection of gas in the bowel, shows a lessened or a minus density.

Normal kidneys or psoas muscles, normal bone, and the commonly found collections of gas in the bowel (on a properly taken film) may, therefore, be considered as standards of the various densities and used as basic guide in the interpretation of such films.

If we carefully examine the two psoas muscles on this film (Areas III and IV), it is easy to see that Area III is much wider and its border quite indistinct as compared to Area IV. In the absence of evidence of disease in the adjacent bones or joints (on complete x-ray examination), we have considered these findings indicative of retroperitoneal pathology and usually perinephritic abscess such as was found in this case.

In this instance the abnormal soft tissue markings are of definite diagnostic value without the use of any special measures, some of which might have obscured the difference in the psoas markings.

Fig. 2. In this film of the unprepared abdomen and pelvis we see three arrows pointing to an area of increased (plus) density in the left pelvic region which, on close examination, showed at least part of one tooth. The interpretation of dermoid cyst of the ovary was proven at operation. The patient was referred for gastrointestinal examination, but the ovarian tumor proved to be the cause of the complaint, and no further x-ray examination was made. These shadows might have been very difficult to interpret, or possibly overlooked, had any opaque material been used.

ing some calcium, calcified mesenteric and omental glands, renal and ureteral stones, calcifications occasionally seen in the parenchyma of the kidney, its pelvis and calices; phleboliths along the lower lateral margins of the pelvic outlet, and occasionally ureteral and bladder calculi. Less common shadows in this group include calcifications in various organs, as uterus and ovary, especially when the latter contains teeth or other dense elements (Fig. 2). One may also be surprised to find forgotten opaque foreign bodies such as Murphy buttons (Fig. 3) and bullets.

When any of the above mentioned or similar lesions are suspected it is absolutely essential to make use of the preliminary film of the abdomen or a pair of stereoscopic films may be made if desired to enable one to make a survey of the entire area before any further examination is attempted. The value of this preliminary film of the abdomen in the chronic as well as in the acute cases is not sufficiently appreciated by the average practitioner of medicine. The dilated coils of the acutely obstructed small bowel filled with gas cast a minus density shadow (Fig. 4). The

Fig. 3.

Fig. 4.

Fig. 3. In this film the arrow points to an area of increased (plus) density which proved to be a Murphy button which had been in the small bowel for an unknown length of time. Twenty-three years before it had been used in surgical repair on a gastric lesion, and as the patient remained in good health for several years he forgot the type of operation performed, and this metallic foreign body was overlooked during two recent gastro-intestinal x-ray examinations. The patient is a physician.

Fig. 4. In this illustration the area indicated by the arrow and the letter *A* is the gas-filled stomach, while below this are several coils of small bowel lying transversely across the abdomen, indicated by the letter *B*. The close-set haustral markings in the walls of this distended gut serve to identify it as small bowel. The Wangensteen tube may be seen entering the stomach just below the upper letter *A* and passing upward along the greater curvature of the stomach.

The use of the barium meal is contra-indicated at this time for this patient.

characteristic haustral markings of the small intestine are visible and sufficiently significant in such cases so that it is unnecessary to resort to the use of a barium meal which may greatly embarrass an already distended gut. We never use a barium meal in the acute abdomen without first having a preliminary film, and if a distended small bowel is present, no barium is used; if the large bowel is distended, a barium enema is given. In rare instances when it is necessary to use barium by mouth, a very small amount of the barium meal will suffice.

In our opinion all examinations of the gastro-intestinal tract, even in chronic cases, should begin with at least preliminary films of the gall bladder or, as stated before, the large preliminary film including the entire abdomen. If a perforation of the intestine with free air or fluid in the peritoneal cavity (Fig. 5) is present or a subphrenic abscess is suspected (Fig. 6), a film in the upright position must be taken. If the patient is unable to stand, he may sit up and the film must include the lower lung-fields, at least the full shadows of the diaphragms. This takes but little time, and the expense is not at all prohibitive.

If the large preliminary film of the abdomen is not taken, we usually take two of the gall-bladder area for comparison with later films and to compare with each other, before any opaque substance is given, as frequently one film leaves us with a very poor idea as to whether or not there are any calculi in the gall bladder. The large preliminary film of the unprepared abdomen has been of such great help to us, particularly in cases of partial intestinal obstruc-

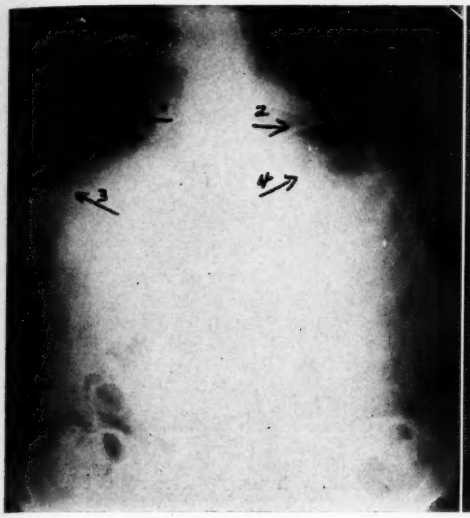

Fig. 5. Fig. 6.

Fig. 5. In this illustration the arrows *1* and *2* point toward the right and left diaphragms, respectively, each of which shows as a line of increased density reaching to the lateral chest wall. Immediately beneath the elevated diaphragm on each side are areas of lessened (minus) density due to free gas. Arrow *3* points toward a fluid level; the free gas and free fluid in this region are usually found in a subphrenic abscess, while the free gas under the left diaphragm means free air in the peritoneal cavity, and the findings under the two diaphragms are characteristic of perforated intestine. This is a preliminary or survey film taken with patient standing. The usual prone film was taken and showed nothing.

It is absolutely essential, if free air is suspected under either diaphragm, that the patient be taken standing or sitting up. The information gained makes the procedure worth the added danger to the patient.

Since we know from our work with pneumoperitoneum that gas is readily absorbed, it is well to bear in mind that if no free gas is demonstrable it is not absolute evidence that there has been no perforation, especially if some time has elapsed between the onset of symptoms and the time the roentgenogram was made.

Peritonitis due to gas-forming organisms may also give rise to free gas in the abdomen.

Fig. 6. In this illustration we have the cardinal findings of a subphrenic abscess. The right diaphragm (*arrow 1*) is elevated, thickened, and lies over an area of lessened (minus) density due to a collection of free gas (*arrow 2*) which, in turn, lies immediately above some free fluid (*arrow 3*) above the liver. The normal diaphragm (*arrow 4*), and the normal collection of gas in the cardiac end of the stomach, may be seen on the left side. Note the difference in the position of the two diaphragms, also the abnormal thickening on the right.

tion, atypical ureteral stones, and similar cases, that we have come to believe it should be the routine in examinations of the trunk in which a contrast medium may be used later or in which surgery is contemplated.

In the summer, when the heat is extreme over a long time and the use of cold drinks and cold foods is so prevalent that many intestinal upsets occur, some of which result in acute partial obstructions, we are called upon to x-ray many acute abdomens. Our first and very often our only procedure is a flat film of the abdomen. It is surprising—the number of small bowel dilatations that we find and how quickly they respond to therapy, the principal item of which is the use of the Wangensteen (Fig. 4) suction tube, draining the upper intestinal tract through the mouth.

Another place in which we feel that a preliminary film of the abdomen is an essential part of the routine is in all cases of suspected acute appendicitis. The occasional demonstration of low ureteral calculus in these cases leads one to have great respect for this simple procedure, and we believe that in time—and by that, we mean before long—it will be unfair and unjust to any patient to do a laparotomy on him if the diagnosis is at all in doubt, without this preliminary film of the unprepared patient.

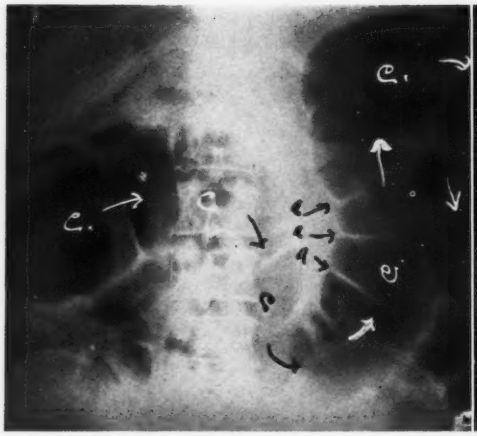

Fig. 7.

Fig. 8.

Fig. 7. In this illustration we have an obstructed large bowel filled with gas. The course of the gut, as indicated by Arrow *C*, and the width of the haustral markings, as indicated by Arrow *A*, are the significant features and are well shown without any preparatory measures.

Fig. 8. In this illustration we see several small collections of gas above fluid levels—these small gas bubbles are at various levels of the abdomen and are characteristic findings of an obstructed small gut when the film is taken with the patient in the upright position.

The acute distention accompanying obstructions due to various causes, functional and organic, may occasionally be diagnosed by the fluoroscope but are best demonstrated, as before mentioned, by the preliminary film of the abdomen without the use of any opaque substances. In the absence of these dilated coils of small intestine or the wider loops of distended large bowel on the preliminary film, one is justified in concluding that no—or only partial—obstruction is present. The small bowel markings, as seen in the distended gut with acute obstruction, are quite different from the haustral markings of the distended gut which has been partially obstructed over a long period of time. The haustral markings in the acutely obstructed small gut are close together and give one the idea of a herring-bone arrangement (Fig. 4). The more chronically obstructed small gut shows possibly a little less distention, and the haustral markings are irregular and a little farther apart, but not so far apart nor so uniform in appearance as the normal haustral markings in the colon. The location and course of this distended small gut are also of diagnostic importance, being more centrally located than the colon, and its course is usually transversely back and forth across the abdominal field. In the colon the haustral markings are much farther apart, and the width of the large gut (Fig. 7), when distended due to obstruction is much greater than normal. Both the large and the small gut are about twice their normal width when distended, making the obstructed small gut about the width of the normal large gut. The identification of the acutely obstructed small gut rests on the numerous close-set haustral markings when taken in the prone position, and multiple small gas bubbles and fluid levels when taken in the upright position (Fig. 8). Since the colon when obstructed is about twice its normal width and shows the widely spaced haustral markings, it seems that it should not be confused with the small bowel markings, even though the latter are distended.

The possibility of a pneumonia with predominating abdominal symptoms can usually be definitely settled with a fluoroscopic examination of the chest, as generally there is sufficient early consolidation present to permit one to draw the right conclusions; however, this is not always so. We formerly thought one could not have

pneumonia without sufficient pulmonary consolidation to cast significant x-ray shadows, but after observing two cases which were suspected of pneumonia, but in which appendicitis was also seriously considered, go on to demonstrate consolidation on the 24-hour observation, the lung being entirely negative at the time of the first observation, we are convinced that occasionally one may not have sufficient pulmonary change in an early pneumonia to permit of the absolute diagnosis on the fluoroscope. Therefore, if the case is very early—a matter of some hours—one should not be too emphatic in his opinion that pneumonia is not a possibility. A film of the chest would be, of course, more accurate in showing a slight change than would the fluoroscope, and in certain cases both methods of x-ray examination should be employed; in the very early cases at least a 12-hour interval might be allowed to observe what change, if any, has taken place in the lung shadows.

So much for the use of the fluoroscope and preliminary film in the acute abdomen without the use of contrast media in the diagnosis of acute abdominal conditions. Consideration of the use of contrast medium has been purposely left to the last because it is but seldom used in the acute cases.

If the gall bladder is suspected of being the major cause of complaint, of course we use the gall-bladder dye as a routine measure after taking preliminary films of the gall-bladder area. We use the oral method of dye examination, and if the shadow is absent or indistinct on the first day's examination, we give another dose of the dye that evening and re-examine the patient the next day. This gives us very distinct shadows in many instances in which the single dose of dye has given us no—or but a doubtful—shadow. The preliminary films of the gall bladder without dye will, as everyone knows, show only the opaque or calcium-containing gallstones and since these make up such a small percentage of the total number of gallstones, the films without the dye are of limited value only. However, since the preliminary films of the gall bladder show the opaque stones when present, and the dye in the functioning gall bladder serves to outline the non-opaque stones when present, as well as to assist in localizing opaque and non-opaque suspicious shadows in the gall-bladder area, one is well able at the present time to determine whether or not the patient has gallstones, particularly if the gall bladder is functioning.

The value of the Graham-Cole procedure cannot be overestimated and is best appreciated by the early workers who struggled hard to demonstrate an occasional calcium stone, while to-day it is a daily occurrence with the aid of the dye to determine whether or not a gall bladder is functioning, and often, when functioning, to show numerous non-opaque stones. At the present time the full use of the x-ray and the Graham-Cole method is an essential step in the diagnostic procedure if the gall bladder is at all suspected.

SUMMARY

To summarize briefly, one must keep in mind that both the gall bladder and lower intestinal tract should have a preliminary film of the suspected area before any opaque medium is given to the patient by mouth or intravenously, or barium or gas given *per rectum*. After the preliminary film one may follow a routine form of examination or vary it to suit the requirements of the special case. One must keep in mind that opaque shadows in the gall bladder may be obscured by administering opaque gall-bladder dye before the preliminary film is taken; on the other hand, cholesterin or non-opaque stones not evident on the first film may be brought into plain view by the use of the opaque gall-bladder dye in a functioning gall bladder. One may be similarly confused with the use of opaque medium in the kidney, ureter, and bladder regions covering an opaque pathologic shadow before a preliminary film has been taken. The same may also be said concerning the omental calcifications which become confused with the opaque shadow of the

small bowel if the barium meal has been given. The demonstration of the distended small gut, when present, is also quite important, lest barium be added to an already overtaxed viscus in cases of partial or complete obstruction. Therefore, to be accurate and thorough, a film of the entire abdomen should be routinely taken before many of the present-day contrast methods of examination are initiated.

The purpose of this short paper is not to bring out anything new or original but to make us more thoughtful in the use of the measures we have at our disposal, and particularly to stress the value of preliminary films of the acute surgical abdomen and also before the usual gall-bladder, gastro-intestinal, or genito-urinary examinations are made with the use of any contrast medium. No attempt has been made to minimize the advantages of contrast methods, and the value of such measures in gall-bladder examinations are shown to offset the formation of such an impression. It is the sequence of the methods to be used which should be given the utmost consideration in every examination lest the wrong method be used first. The only way the proper sequence of methods can possibly be employed is through the co-operation or the teamwork of the various physicians on the case, each one endeavoring to help the other, and not—as is often the case—holding out some important findings just to see how much the other method will reveal. For the good of the patient, frankness and teamwork by all concerned is every physician's duty.

CASE REPORTS

MULTIPLE CHONDROMAS

By JOHN DAY PEAKE, M.D., *Mobile, Alabama*

In presenting the following case of multiple chondroma, I appreciate that cases of chondroma are not uncommon. However, the following case demonstrates a chondroma in one of the long bones of the forearm, which is not a common site for such a tumor. This case is of some interest because it was treated with radiation with good results and not by surgery, which form of treatment is so frequently employed in some quarters.

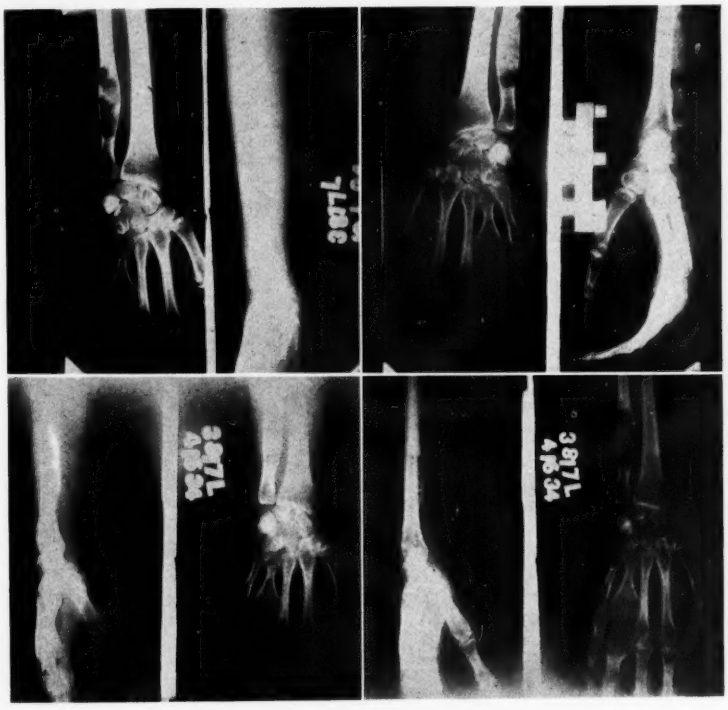

Fig. 1. Case of multiple chondromas.

Patient (H. M.), white female, aged 20 years, apparently in good health. In 1933, while driving an automobile, patient fractured lower third of left forearm. Was treated as a fracture, but no x-rays were taken for several months, and at that time cystic bone changes with trabeculation were noted in lower end of ulna, distal end of fourth metacarpal, proximal phalanges of ring and little fingers. These cystic changes were a thinning of the bone near the epiphyseal line. No destruction and no periosteal involvement. X-ray examination of the following: skull, pelvis, chest, dorsal spine, shoulders, both legs and feet, all revealed no bone changes other than a small area of increased radiability in the lower third of the left tibia, in anterior aspect of left medullary canal. No other destruction or proliferation noted. No elevation of periosteum.

General physical examination did not reveal any gross abnormal findings other than tumefaction of lower third of left forearm, left ring and little fingers.

No abnormal findings in the blood, urine, stool, blood calcium, or phosphorus.

Past history: Usual childhood diseases with no complications. Pneumonia, influenza, tonsils and adenoids, no complications. Left hand, crushed in childhood, apparently healed normally. Family history, irrelevant; menstrual history, normal; system history, normal.

Progress: This patient was given medium doses of x-ray (300–600 r) — 180 kv. p., 0.5 mm. Cu, 1 mm. Al filter, distance 60 cm., port 5X5 at intervals, calcium and vitamin therapy.

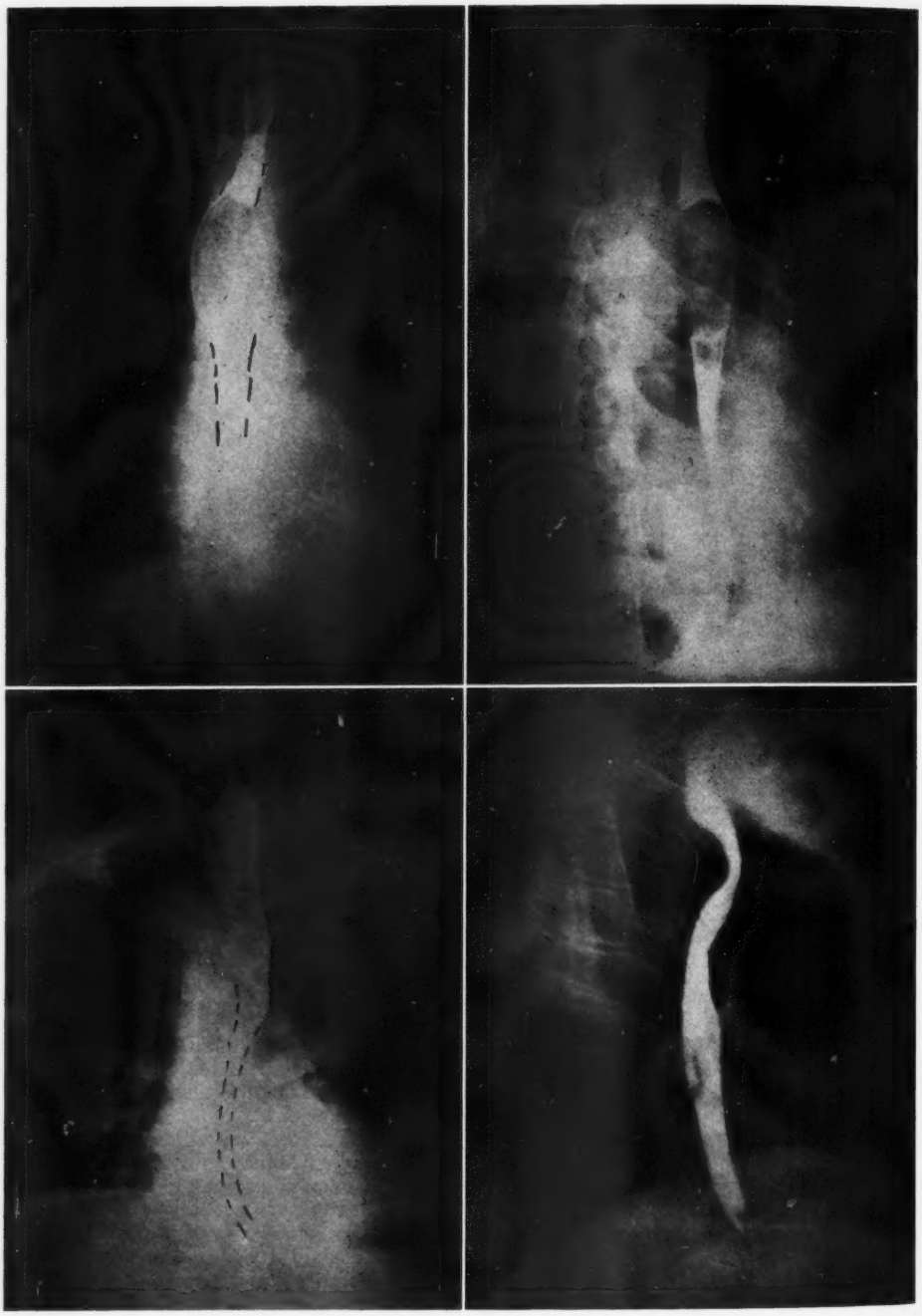

Fig. 1 (*upper left*). Case 1. Fig. 2 (*upper right*). Case 1. Fig. 3 (*lower left*). Case 2. Fig. 4 (*lower right*). Case 2. (*With Anomalies of Aortic Arch. See next page.*)

We have watched this patient at intervals for the past three years. The x-rays of the left forearm and hand show a definite increase in bone with a decrease in cystic changes. No change in left tibia. Now the patient apparently is healthy and active; she is careful not to injure her arm.

I am indebted to John C. Hope, M.D., for the opportunity of studying this case.

ANOMALIES OF THE AORTIC ARCH

By MILA J. KINNEY, M.D., ELMER LILJEDAHL, M.D., *and* RICHARD T. TAYLOR, M.D.,
Los Angeles, Calif.

Anomalies of the aortic arch are not considered rarities but, nevertheless, they present at times problems which are both interesting and important.

In order to appreciate and understand the various anomalies to which the aorta is susceptible one must have a clear understanding of the normal aorta, which as we know, at times varies even within the normal. For these reasons we are presenting two such interesting cases.

Case 1. A man, aged 28, was sent in for gastro-intestinal examination on Nov. 11, 1936. There were no symptoms referable to pressure on the esophagus. However, on close questioning he said he had noticed, for as long as ten years, an occasional sensation of obstruction in swallowing. The normal aortic shadow on the left was absent, with a decided prominence on the right side. In the first oblique position, the esophagus could be seen taking a course anterior to the aorta. There was no evidence of an aneurysmal dilatation or the presence of syphilis.

Diagnosis: Anomaly of the aortic arch.

Case 2. A man, aged 40, complained of no symptoms referable to pressure on the esophagus, and careful questioning could not break down this statement. As in Case 1, the normal aortic knob on the left was absent but was seen clearly on the right. In the lateral position, the esophagus can be seen displaced anteriorly at the level of the arch.

Diagnosis: Right-sided aortic knob.

RADIOLOGICAL SOCIETIES IN THE UNITED STATES

CALENDAR

MEETINGS FALLING BETWEEN THE DATES OF JULY 15 AND AUGUST 31

July 15–17. Denver Radiological Club midsummer meeting at Shirley-Savoy Hotel, Denver, Colo.

Editor's note.—Will secretaries of societies please co-operate with the Editor by supplying him with information for this page.

CALIFORNIA

CALIFORNIA MEDICAL ASSOCIATION, SECTION ON RADIOLOGY. *Chairman*, John D. Lawson, M.D., 1306 California State Bldg., Sacramento; *Secretary*, Karl M. Bonoff, M.D., 1930 Wilshire Blvd., Los Angeles. Meets annually with California Medical Association.

LOS ANGELES COUNTY MEDICAL ASSOCIATION, RADIOLOGICAL SECTION. *President*, D. R. McColl, M.D.; *Vice-president*, John F. Chapman, M.D.; *Secretary*, E. N. Liljedahl, M.D.; *Treasurer*, Henry Snure, M.D. Meets every second Wednesday of month at County Society Building.

PACIFIC ROENTGEN CLUB. *Chairman*, Raymond G. Taylor, M.D., 1212 Shatto St., Los Angeles; *Secretary*, L. Henry Garland, M.D., 450 Sutter St., San Francisco.

COLORADO

DENVER RADIOLOGICAL CLUB. *President*, W. Walter Wasson, M.D., 246 Metropolitan Bldg.; *Vice-president*, Ernst A. Schmidt, M.D., Colorado General Hospital; *Secretary*, Nathan B. Newcomer, M.D., 306 Republic Bldg.; *Treasurer*, Leonard G. Crosby, M. D., 366 Metropolitan Bldg. Meets third Tuesday of each month at homes of members. Midsummer Conference, Shirley-Savoy Hotel, July 15–17.

CONNECTICUT

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY. *Chairman*, Kenneth K. Kinney, M.D., 29 North Street, Willimantic; *Vice-chairman*, Francis M. Dunn, M.D., 100 State Street, New London; *Secretary-treasurer*, Max Climan, M.D., 242 Trumbull St., Hartford. Meetings twice annually in May and September.

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FLORIDA STATE RADIOLOGICAL SOCIETY. *President*, Gerald Raap, M.D., 168 S. E. First St., Miami; *Vice-president*, H. O. Brown, M.D., 404 First Nat'l Bank Bldg., Tampa; *Secretary-treasurer*, H. B. McEuen, M.D., 126 W. Adams St., Jacksonville.

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CHICAGO ROENTGEN SOCIETY. *President*, David S. Beilin, M.D., 411 Garfield Ave.; *Vice-president*, Chester J. Challenger, M.D., 3117 Logan Blvd.; *Secretary-treasurer*, Roe J. Maier, M.D., 7752 Halsted St. Meets second Thursday of each month, September to May, except December.

ILLINOIS RADIOLOGICAL SOCIETY. *President*, Ivan Brouse, M.D., 316 W. State, Jacksonville; *Vice-president*, Cesar Gianturco, M.D., Carle Hospital Clinic, Urbana; *Secretary-treasurer*, Edmund P. Halley, M.D., 968 Citizens Bldg., Decatur. Meetings quarterly by announcement.

ILLINOIS STATE SOCIETY, SECTION OF RADIOLOGY. *President*, Roswell T. Pettit, M.D., 728 Columbus St., Ottawa; *Secretary*, Ralph G. Willy, M.D., 1138 N. Leavitt St., Chicago. Eighty-seventh annual meeting at Peoria, May 18–20.

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IOWA

THE IOWA X-RAY CLUB. Holds luncheon and business meeting during annual session of Iowa State Medical Society.

MAINE

See New England Roentgen Ray Society.

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BALTIMORE CITY MEDICAL SOCIETY, RADIOLOGICAL SECTION. *Secretary*, H. E. Wright, M.D., 101 W. Read St., Baltimore. Meetings each Monday night.

MASSACHUSETTS

See New England Roentgen Ray Society.

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DETROIT X-RAY AND RADIUM SOCIETY. *President,* C. C. Birkelo, M.D., Herman Keifer Hospital; *Vice-president,* E. W. Hall, M.D., 10 Peterboro St.; *Secretary-treasurer,* E. R. Witwer, M.D., Harper Hospital. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society Bldg.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS. *President,* J. C. Kenning, M.D., 1536 David Whitney Bldg., Detroit; *Vice-president,* A. W. Chase, M.D., 133 Toledo St., Adrin; *Secretary-treasurer,* C. S. Davenport, M.D., 609 Carey St., Lansing.

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THE ST. LOUIS SOCIETY OF RADIOLOGISTS. *President,* Joseph C. Peden, M.D., 634 N. Grand Blvd.; *Secretary,* W. K. Mueller, M.D., 607 N. Grand Blvd. Meetings fourth Wednesday of each month.

NEBRASKA

NEBRASKA STATE RADIOLOGICAL SOCIETY. *President,* Howard B. Hunt, M.D., 4740 Hickory St., Omaha; *Secretary,* D. Arnold Dowell, M.D., 117 S. 17th St., Omaha. Meetings first Wednesday of each month at 7 P.M. in Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY

(Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.) *President,* A. E. O'Connell, M.D., 390 Main St., Worcester, Mass.; *Secretary,* E. C. Vogt, M.D., 300 Longwood Ave., Boston. Meetings third Friday of each month from October to May, inclusive, usually at Boston Medical Library.

NEW HAMPSHIRE

See New England Roentgen Ray Society.

NEW JERSEY

NEW JERSEY STATE RADIOLOGICAL SOCIETY. *President,* W. W. Maver, M.D., 532 Bergen Ave., Jersey City; *Vice-president,* J. D. Tidaback, M.D., 382 Springfield, Summit; *Secretary,* P. S. Avery, M.D., Middlesex General Hospital, New Brunswick. Meetings at Atlantic City at time of State Medical Society, and Midwinter in Newark as called by President.

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CENTRAL NEW YORK ROENTGEN-RAY SOCIETY. *Secretary,* Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse.

ROCHESTER ROENTGEN-RAY SOCIETY. *Chairman,* Jos. H. Green, M.D., 277 Alexander St.; *Secretary,* S. C. Davidson, M.D., 277 Alexander St. Meetings at convenience of committee.

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RADIOLOGICAL SOCIETY OF NORTH CAROLINA. *President,* Robert P. Noble, M.D., 127 W. Hargett St., Raleigh; *Vice-president,* A. L. Daughtridge, M.D., 144 Coast Line St., Rocky Mount; *Secretary-treasurer,* Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meetings with State meeting in May, and meeting in October.

OHIO

RADIOLOGICAL SOCIETY OF THE ACADEMY OF MEDICINE (Cincinnati Roentgenologists). *President,* George Benzeng, M.D., St. Elizabeth Hospital, Covington, Ky.; *Secretary-treasurer,* Justin E. McCarthy, M.D., 707 Race St., Cincinnati, Ohio. Meetings held third Tuesday of each month.

PENNSYLVANIA

PENNSYLVANIA RADIOLOGICAL SOCIETY. *President,* W. E. Reiley, M.D., Clearfield; *First Vice-President,* Charles S. Caldwell, M.D., 520 S. Aiken Ave., Pittsburgh; *Second Vice-president,* Louis A. Milkman, M.D., Medical Arts Bldg., Scranton; *Secretary-treasurer,* Lloyd E. Wurster, M.D., 416 Pine St., Williamsport; *President-elect,* Sydney J. Hawley, M.D., Geisinger Memorial Hospital, Danville. Annual meeting, May 21–22, Erie.

PHILADELPHIA ROENTGEN RAY SOCIETY. *President*, Thomas P. Laughery, M.D., Germantown Hospital; *Vice-president*, Elwood E. Downs, M.D., Jeans Hospital, Fox Chase; *Secretary*, Barton H. Young, M.D., Temple University Hospital; *Treasurer*, R. Manges Smith, M.D., Jefferson Hospital. Meeting first Thursday of each month from October to May, Thompson Hall, College of Physicians, 19 S. 22nd St., 8:15 P.M.

RHODE ISLAND

See New England Roentgen Ray Society.

SOUTH CAROLINA

SOUTH CAROLINA X-RAY SOCIETY. *President*, Robert B. Taft, M.D., 105 Rutledge Ave., Charleston; *Secretary-treasurer*, Hillyer Rudisill, M.D., Roper Hospital, Charleston. Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

SOUTH DAKOTA

Meets with Minnesota Radiological Society.

TENNESSEE

MEMPHIS ROENTGEN CLUB. Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

TENNESSEE STATE RADIOLOGICAL SOCIETY. *President*, H. S. Shoulders, M.D., 246 Doctors Bldg., Nashville; *Vice-president* S. S. Marchbanks, M.D., 508 Medical Arts Bldg., Chattanooga; *Secretary-treasurer*, Franklin B. Bogart, M.D., 311 Medical Arts Bldg., Chattanooga. Meeting annually with State Medical Society in April.

VERMONT

See New England Roentgen Ray Society.

VIRGINIA

RADIOLOGICAL SOCIETY OF VIRGINIA. *President*, Fred M. Hodges, M.D., 100 W. Franklin St., Richmond; *Vice-president*, L. F. Magruder, M.D., Raleigh and College Aves., Norfolk; *Secretary*, V. W. Archer, University of Virginia Hospital, Charlottesville.

WASHINGTON

WASHINGTON STATE RADIOLOGICAL SOCIETY. *President*, H. E. Nichols, M.D., Stimson Bldg., Seattle; *Secretary*, T. T. Dawson, M.D., Fourth and Pike Bldg., Seattle. Meetings fourth Monday of each month at College Club.

CONNECTICUT

THE CONNECTICUT STATE MEDICAL SOCIETY SECTION ON RADIOLOGY met during the State Society's One hundred and Forty-fifth Annual Meeting at Bridgeport, May 19–20, 1937. George Levene, M.D., of Boston, Mass., presented in the program of the Section of Radiology, on May 19, a paper on "The Value of Roentgenologic Study in the Diagnosis of Heart Disease."

At the business meeting following the program, the officers elected for the coming year were: *Chairman*, Kenneth K. Kinney, M.D., Willimantic; *Vice-chairman*, Francis M. Dunn, M.D., New London; and re-elected *Secretary-treasurer*, Max Climan, M.D., Hartford.

OHIO

The May meeting of the CINCINNATI RADIOLOGICAL SOCIETY has as its guest M. A. Loebell, M.D., of Zanesville, Ohio, who gave an address on his experimental therapy tube.

George Benzeng, M.D., of Covington, Ky., former *Secretary-treasurer*, of the Radiological Society of the Academy of Medicine, Cincinnati, Ohio, was elected *President*, and Justin E. McCarthy, M.D., of Cincinnati, *Secretary-treasurer*.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor* HOWARD P. DOUB, M.D., *Associate Editor*

GROUP HOSPITALIZATION[1]

Group hospitalization, by its very name, connotes that the relationship is one of direct arrangements between hospitals and groups and that the use of hospital facilities alone is the service bargained for. Group hospitalization, then, is a plan whereby a hospital or an association of hospitals contracts with classified groups of persons to furnish hospital care when needed in return for the periodic payment or prepayment of a stipulated sum by every member of the group. A *bona fide* group hospitalization plan should exclude all professional or medical services of physicians or surgeons, pathologists, roentgenologists, physical therapists, anesthetists, and special nurses. Strictly speaking, these plans should deal only with groups of a homogeneous nature (teachers, department store employees, transportation employees, and others) to lessen the problems of collecting subscriptions and securing the enrollment of good risks. However, if a sufficiently large number of individuals can be secured, they are frequently enrolled as a special group at a slightly higher rate.

The principles essential to an effective group hospitalization plan were outlined in a report of the experience of an early plan as follows[2]:

1. Organization must deal with groups, not with individual risks.

2. Groups must be employed, full-time wage earners. Intermittent employment, such as teaching, nursing, etc., brings much higher actuarial risk.

3. The total number of members—spread in all groups to make the law of averages safely apply—should be at least 3,000 to 5,000.

4. Group hospitalization should give only *hospital* service and should not in any case give service that in any way competes with the physician's professional service. You have to depend on your medical staff to protect the hospital from malingering of patients. We have had no loss on this score.

5. We allow the patients belonging to groups full liberty of choice as to the physician treating him in the hospital.

6. A long-time commitment to a fixed rate should be avoided. One of the best by-products of such group policy is that coming to the hospital with the bill already provided for educates patients to be hospital-minded and will increase hospital patronage and eventually bring a higher rate.

7. Different types of employed groups present varying actuarial risks as to sickness and differing desires as to the types of accommodations. For instance, bank employees are better actuarial health risks than laundry employees, but desire better accommodations, so we make the same rate for both groups but contract for different accommodations for each group.

8. In our own hospital we have definitely adhered at all times to the policy of dealing directly with the groups through the employer or other representative, and we have never employed any outside selling organization or middleman representative. We feel that this is far the safer course.

It should be observed that particular emphasis was placed on such matters as the preference for group risks, desirability of full-time employment of members and a minimum number of members, hospital service only, freedom of choice, no fixation of rates or provisions, allowances for different actuarial risks, and no intervening third party.

Perhaps the best method of explaining the bases on which the group hospitalization plan is founded would be to follow a schematic outline of a fictitious plan, as follows: (1) expected enrollment, (2) expected hospitalization, (3) expected costs.

Enrollment estimates are based primarily on the number of gainfully occupied persons in the community. While the estimates of the pro-

[1] Reprinted by permission from "Journal of American Medical Association," May 29, 1937, **108,** 180B.

[2] Kimball, J. F.: Group Hospitalization. Trans. Am. Hosp. Assn., 33d Annual Convention, Toronto, Canada, 1931, p. 667.

portion of employed groups that will be enrolled vary all the way from 6 to 50 per cent, it is estimated that about 10 per cent will become subscribers (the enrollment of dependents will not be considered, for the sake of simplicity). For a community of 100,000 employed persons it would therefore be estimated that 10,000 persons would subscribe to the plan.

The expected hospitalization will necessarily vary according to the benefits and limitations of the contract and the type of community, but it is generally accepted that about one patient day per member annually will be the hospitalization experience. Accordingly, it is expected that about 10 per cent of the membership will be hospitalized for an average stay of ten days. In other words, for the membership of 10,000, about 1,000 persons would be hospitalized for a total period of 10,000 days each year.

In the determination of the costs, a flat sum of, say, $6 per member is estimated to be adequate to pay for the average patient day cost, including allowances for bed and board, operating room, anesthetic, routine laboratory services, and routine medicines; $3 per member is allowed for the cost of administration, sales and reserves, and a $1 enrollment fee is charged for initial recording or to cover promotional expenses. The total cost to the subscriber, for the first year, would be $10.

Under the fictitious plan, then, the income from the 10,000 subscribers would be $100,000. The expected costs of hospitalization would be $60,000 ($6 per patient day for 10,000 days). The difference between this anticipated liability and the total revenue, or $40,000, would be available for all other costs. Roughly, the administrative costs are expected to be 10 per cent of the total income and the promotional and sales costs 20 per cent, or a total of $30,000. Finally, the remaining $10,000 would be utilized to create reserves and a surplus.

In an abruptly simple form, these are the fundamental factors on which the group hospitalization plan is based. No one plan would be organized exactly according to the method outlined, but, while the percentages would vary or the costs might be allocated in a different proportion, each group hospitalization plan is formulated approximately on the bases indicated.

Even within this more uniform concept of what a group hospitalization plan is, there seem to be four different types of plans: (1) single hospitals not employing sales agencies, (2) non-commercial associations or groups of hospitals not employing sales agencies, (3) a sales agency contracting with a single hospital, and (4) commercial associations or sales agencies contracting with several hospitals.

NOTE.—This is the fifth of a series of articles on Group Hospitalization, prepared by the Bureau of Medical Economics of the Association, which is to be published weekly in the "American Medical Association Organization Section." When completed, the series will be available in reprint form on request at the headquarters of the Association.

ANNOUNCEMENTS

PROGRAM OF THE FIFTH INTERNATIONAL CONGRESS OF RADIOLOGY

Sept. 13 to 17, 1937

The program of the Fifth International Congress of Radiology is now complete. It has been arranged under the following divisions:

I. Opening session on Monday evening, September 13, at which addresses will be delivered by Dr. William J. Mayo, Dr. Gösta Forssell, Dr. H. R. Schinz, and Dr. A. C. Christie.

II. Four full sessions of the Congress occupying the entire forenoons from Tuesday to Friday, inclusive. The following is a partial list of authors and subjects for these general sessions:

The Production of X-rays of Very Short Wave Length, Dr. William D. Coolidge, Schenectady, New York, U. S. A.

Ionization by High Voltage X-rays and Gamma Rays. Dr. Arthur H. Compton, Chicago, Illinois, U. S. A.

Cancer of the Larynx. Dr. Henri Coutard, Paris, France.

Racial Variations in the Incidence of Carcinoma. Dr. Max Cutler, Chicago, Illinois, U. S. A., and Sir George Lenthal Cheatle, England.

The Rôle of the Autonomous Movements of the Gastro-intestinal Mucous Membrane in Digestion. Prof. Gösta Forssell, Stockholm, Sweden.

The Treatment of Hodgkin's Disease by Radiotherapy. Dr. Réné Gilbert, Geneva, Switzerland.

Main Lines in Technical or Biological Studies of Radiation Therapy Methods. Prof. Hans Holfelder, Frankfurt-am-Main, Germany.

Important Points in the Roentgen and Radium Therapy of Tumors. Prof. Hermann Holthusen, Hamburg, Germany.

The Development of High Voltage X-ray Tubes at the California Institute of Technology. Dr. Charles C. Lauritsen, Pasadena, California, U. S. A.

Production and Biological Effects of Neutrons. Dr. Ernest O. Lawrence, Berkeley, California, U. S. A.

The Radiological Evaluation of the Size and Form of the Heart. Prof. Gian Giuseppe Palmieri, Bolognia, Italy.

The Use of the Roentgen Rays in the Diagnosis and Treatment of Tumors of the Bladder. Dr. George E. Pfahler, Philadelphia, Pennsylvania, U. S. A.

Physical and Biological Dosage. Prof. Mario Ponzio, Turin, Italy.

Movements of the Esophagus, Stomach, Duodenum, and Ileum as Revealed by Cineradiographic Films. Dr. Russell J. Reynolds, London, England.

Diagnosis, Pathology, and Roentgen Treatment of Peritendinitis Calcarea. Dr. Carl Sandström, Stockholm, Sweden.

Cerebral Cystography and Cisternography. Prof. Arthur Schüller, Vienna, Austria.

Teleroentgentherapy. Dr. Felix Sluys, Brussels, Belgium.

Roentgen Kymography as a Diagnostic Help. Prof. Pleikart Stumpf, Munich, Germany.

The Production of Penetrating Radiations by Means of Electrostatic Generators. Dr. Robert G. Van de Graaff, Cambridge, Massachusetts, U. S. A.

Bronchial Carcinoma; A Roentgen-pathological Study. Dr. Nils Westermark, Stockholm, Sweden.

In addition to the above subjects, there will be reports from Austria, France, Germany, Great Britain, Italy, and the United States on the present status of education and organization in radiology. During these sessions, there also will be reports by the Chairmen of the International Committee on Radiological Units and the International Committee on Protection. At a special afternoon session, Dr. Russell J. Reynolds, of London, and Dr. Maurice Van de Maele, of Brussels, will give reports and demonstrations of the indirect and direct methods of cinematography.

III. Three evening sessions of the Congress, namely, Tuesday, Wednesday, and Thursday, are devoted to the three special annual lectures given under the auspices, respectively, of the American Radium Society, The American Roentgen Ray Society, and The Radiological Society of North America. Dr. Douglas Quick, of New York City, will deliver the Janeway Lecture on "Carcinoma of the Larynx"; Dr. George E. Pfahler, of Philadelphia, will deliver the Caldwell Lecture on "The Treatment of Carcinoma of the Breast," and Dr. George W. Holmes of Boston, the Carman Lecture on "The Development of Post-graduate Teaching in Radiology."

IV. Educational sessions which were announced in this Journal in the March and April numbers will be held from 8:00 to 9:00 A.M. on the mornings of Tuesday, Wednesday, Thursday, and Friday, September 14 to 17, inclusive. These courses are open to all members of the Congress but members must register for the course which they desire to take. The courses are being filled very rapidly and anyone who wishes to take one of them should register at once.

V. The afternoon sessions of the Congress, Tuesday, September 14, to Friday, September 17, inclusive, are organized in the following Sections:

Section I A, Roentgen Diagnosis,
Chairman, Dr. James T. Case.
Section I B, Roentgen Diagnosis,
Chairman, Dr. Charles A. Waters.
Section I C, Roentgen Diagnosis,
Chairman, Dr. Fred M. Hodges.
Section II A, Radiotherapy,
Chairman, Dr. Albert Soiland.
Section II B, Radiotherapy,
Chairman, Dr. B. P. Widmann.
Section II C, Radiotherapy,
Chairman, Dr. A. U. Desjardins.
Section III, Radiophysics,
Chairman, Dr. G. Failla.
Section IV, Radiobiology,
Chairman, Dr. Francis Carter Wood.
Section V, Electrology and Light Therapy,
Chairman, Dr. Norman E. Titus.

It is impossible in this brief notice to list the papers which will be presented before the Sections. Leading workers from every country in the world will present papers on diagnosis, therapy, radiophysics, radiobiology, and electrology on every important subject in the entire field of radiology. The time limit for

presentation of papers will be adhered to strictly and the programs of the various Sections will be so synchronized that any member may arrange for himself a program which will include papers in all of the Sections.

During the month of August, all members of the Congress will receive a preliminary program listing all of the addresses and papers to be presented before the Congress, both in the general sessions and the Sections.

Applications for membership are being received in large numbers in the office of the General Secretary, indicating that there will be a large attendance at the Congress. Since the membership fee includes the right to register for one of the educational courses and attendance at all of the scientific and social events, including the final grand banquet on the closing night, it is important for everyone to complete his membership at the earliest possible moment.

PRELIMINARY PROGRAM OF THE THIRD MIDSUMMER RADIOLOGICAL CONFERENCE

IN THE ROCKY MOUNTAINS, DENVER

This Conference is sponsored by the Denver Radiological Club. The dates are July 15, 16, 17, 1937. There is no registration fee. This program has been designed to better acquaint the entire medical profession with the uses of radiology in diagnosis and treatment. All meetings are to be held in the Hotel Shirley-Savoy (17th Avenue entrance), Denver.

Thursday, July 15

W. W. Wasson, M.D., presiding, President, Denver Radiological Club.

Address of welcome, A. J. Markley, President, Colorado State Medical Society, Denver.

Symposium on the Breast

Anatomy of the Breast

H. C. Tracy, M.D., Department of Anatomy, University of Kansas, Lawrence, Kan.

Pathology of the Breast

Frederick C. Narr, M.D., Pathologist, Research Hospital, Kansas City, Mo.

The Roentgen Examination of the Breast

Ira H. Lockwood, M.D., F.A.C.R., Kansas City, Mo.

Benign Lesions of the Breast

James E. Stowers, M.D., F.A.C.S., Kansas City, Mo.

The Surgical Treatment of Carcinoma of the Breast

Claude J. Hunt, M.D., F.A.C.S., Kansas City, Mo.

The Radiation Treatment of Carcinoma of the Breast

Lewis G. Allen, M.D., F.A.C.R., Asst. Professor of Radiology, University of Kansas, Kansas City, Kan.

Discussion opened by Henry Schmitz, M.D., Chicago.

Joint meeting with the Medical Society of the City and County of Denver, Paul J. Connor, M.D., presiding, President of the Medical Society of the City and County of Denver.

Guest Speakers:

Leo G. Rigler, M.D., Minneapolis, Minn.

The Roentgen Examination in Preventive Medicine.

Henry Schmitz, M.D., Chicago.

The Selection of the Form of Treatment in Uterine Myomas.

General discussion.

Friday, July 16

Recent Advances in Diagnostic Radiology.
Ernst A. Schmidt, M.D., Denver.

Roentgen-ray Pelvimetry and Cephalometry.
Paul C. Hodges, M.D., Chicago.

Roentgen Findings in Pleural Effusions.
Leo G. Rigler, M.D., Minneapolis.

Roentgenologic Studies of the Gastro-intestinal Motor Phenomena.
Leon J. Menville, M.D., New Orleans.

Luncheon, Round Table Discussion of the Problems of Diagnostic Radiology.

Chairman, Frederick E. Diemer, M.D., Denver.

The Demonstration of the Crater in Duodenal Ulcer.
Paul C. Hodges, M.D., Chicago.

Bone Tumors.
Leon J. Menville, M.D., New Orleans.

Saturday, July 17

Recent Advances in Radiation Therapy.
Paul R. Weeks, M.D., Denver.

The Diagnosis, Treatment, and Curability of Intra-oral Cancer.
Hayes E. Martin, M.D., New York.

The Diagnosis and Treatment of Cancer of the Uterus.
Henry Schmitz, M.D., Chicago.

Luncheon, Round Table Discussion of Therapeutic Radiology.
Sanford Withers, M.D., presiding, Denver.

There will be scientific and commercial exhibits.

"The Denver Radiological Club wishes to call attention to the Rocky Mountain Medical Conference, sponsored jointly by the State Medical Societies of Colorado, New Mexico, Utah, and Wyoming, to be held in Denver, July 19, 20, and 21, 1937. An outstanding program will be offered by clinicians and teachers of international reputation. Physicians attending our radiological meeting should remain in Denver a few additional days for this later Conference, which will be open to all members of their respective state medical societies at a nominal registration fee."

THE AMERICAN COLLEGE OF PHYSICIANS

The Twenty-second Annual Session of the American College of Physicians will be held in New York City, with headquarters at the Waldorf-Astoria Hotel, April 4–8, 1938.

Dr. James H. Means, of Boston, is President of the College, and will have charge of the program of general scientific sessions. Dr. James Alex. Miller, of New York City, has been appointed General Chairman of the Session, and will be in charge of the program of clinics and demonstrations in the hospitals and medical schools and of the program of Round Table Discussions to be conducted at headquarters.

A MEMBER HONORED

A former President of the Radiological Society of North America, Arthur W. Erskine, M.D., of Cedar Rapids, Iowa, has been chosen President-elect by his State Medical Society, to succeed Edward M. Meyers, M.D., the president incumbent.

All of Dr. Erskine's friends congratulate him upon this new honor, added to those he has already held. He is a thorough scientist, a charming and accomplished gentleman, and merits the confidence of his colleagues.

IN MEMORIAM

J. D. SOUTHARD, M.D., 1861–1937

Death claimed J. D. Southard, M.D., widely known physician of Fort Smith, Ark., at his home, Sunday, May 9, after a long illness.

A graduate of the University of Louisville Medical School, Dr. Southard was a pioneer in the use of x-ray in the treatment of tuberculosis of the lungs and bones. He read a paper before the Arkansas Medical Society on the "Control of Tuberculosis: A Problem for the United States Government," which was presented in the United States Senate, and by unanimous consent of that body was made a public document and published by the government. He was a fellow of the American Medical Association, a member of the Radiological Society of North America, of which at one time he held office, and a fellow of the American College of Surgeons.

He served in many capacities in the city, county, state, and National governments, acting as medical examiner for four years under the Cleveland administration. For eighteen years he was president of the Fort Smith board of health. Dr. Southard was one of the founders of the first hospital in that city, and was also a member of its staff, and was active in the work of the Arkansas Tuberculosis Sanatorium.

Dr. Southard died at the age of 76 years, after a long illness. He suffered from a metastatic cancer of the right breast from finger epitheliomas.

BOOK REVIEWS

TRAITE DE CHIRURGIE ORTHOPEDIQUE (Volume II). By L. OMBREDANNE, Professeur de clinique chirurgicale infantile et orthopedie à la Faculte de medecine de Paris, membre de l'Academie de medecine, chirurgien de l'hôpital des Enfants-Malades, and P. MATHIEU, Professeur de clinique de chirurgie orthopedique de l'adulte à la Faculte de medecine de Paris, chirurgien de l'hôpital Cochin. A volume of 1,918 pages. Published by Masson et Cie., Paris, 1937. Price for five volumes, complete, 1,250 francs.

The second of this five-volume system of orthopedic surgery brings, first of all, a brief discussion of some of the affections of the nervous system of prime interest to the orthopedist. There is also a review of vascular affections and

of those phases of hematology interesting to the orthopedist, including a chapter on transfusions.

The authors then present a chapter on roentgen diagnosis in orthopedic surgery followed by discussions on all types of apparatus, including plaster and celluloid splints. An extensive review of various types of massage and physiotherapy is then given. These portions of the book are well illustrated and would serve as an excellent guide to any one interested in such phases of treatment.

The remaining portion of the volume then deals with the spine, or, at least, the cervicodorsal and the dorsolumbar portion of the spine.

A discussion of the physiology of the spine in general is first given, followed by a review of the technic of spinal puncture, the roentgenologic technic of the spine, and a discussion of treatment of affections of the spine dealing in a general way with types of fixation for the spine and operative procedures used in surgery of the spine.

In discussing the cervical spine a very excellent review of congenital malformations is given, particularly the Klippel-Feil syndrome, cervical ribs, and torticollis, fractures and dislocations of the atlas and axis, as well as the lower cervical vertebræ, are adequately discussed.

In discussing the dorsolumbar spine a much more extensive review is given, including the congenital anomalies, osteochondritis, sacralization, spondylolisthesis, kyphosis, scoliosis, fractures, and arthritis. A chapter on intervertebral discs is inserted, and syphilis, osteomyelitis, and Pott's disease are discussed.

The chapter on scoliosis is well arranged and a most complete discussion of the widely recognized etiologic theories is presented. We find in it various phases of examination, described in great detail. In the discussion of treatment the authors have not presented the various up-to-date methods used in the United States. We are disappointed to find the method of Abbot described in considerable detail, and the turnbuckle jacket method of Brewster and Lovett described as the method of "John and Lovett." In the operative treatment no mention is made of Lowman's method and the work familiar to us as the product of Hibb's clinic is not well presented.

In connection with the discussion on scoliosis a chapter on various types of exercise suitable for scoliosis is presented.

Fractures of the spine are well discussed and the method of Böhler treatment recommended. In the traumatic lesions of the intervertebral disc the authors refer to the works of Dandy and of Stookey along this line but fail to mention Mixter and Barr, who, to our best knowledge, have done more to modernize the conception of the lesion than anyone else in this country.

On the whole, this volume, as Volume I, is well illustrated and beautifully bound and printed.

Again we are disappointed with the bibliographies which seem to us inadequate for a work of this size and concept. However, again we recognize the fact that the authors have undertaken a large book and to fill a much needed place in orthopedic literature, and we feel that it is a worthwhile volume for anyone interested in bone and joint surgery.

TOMOGRAPHISCHE DIAGNOSTIK DER TUBERKULÖSEN KAVERNE. By KURT GREINEDER, Assistant am Röntgeninstitut der Klinik. Excerpt from Zeitschrift für Tuberkulose, No. 62, 18 pages with 24 illustrations. Published by Johann Ambrosius Barth, Leipzig, 1937. Price: RM. 3.60.

The value of tomography in the delineation of the roentgen findings in pulmonary tuberculosis is detailed in this reprint. The author reports, in some detail, eleven advanced cases in which the tomographic method permitted the demonstration of tuberculous cavities which could not be clearly seen in the ordinary roentgenogram of the chest. In addition, the size and position of cavities, their differentiation from annular shadows and from localized pockets of pneumothorax, and the clarification of other obscure shadows seen in the ordinary roentgenogram can all be determined much more definitely by this method. In essence, these advantages are gained by the obscuration of all structures lying in front or behind the plane in which the tomogram was made. The author does not give any details as to the exact method he uses, but this has been fully covered in other papers from the Roentgen Institute of Professor Chaoul.

DISEASES OF THE NAILS. By V. PARDO-CASTELLO, M.D., formerly Assistant Professor of Dermatology and Syphilology, University of Havana, Cuba. With a Foreword by

HOWARD FOX, M.D., Professor of Dermatology and Syphilology, New York University. A volume of 177 pages with 94 illustrations. Published by Charles C. Thomas, Springfield, Ill., 1936. Price, $3.50, cloth.

This is a short monograph limited entirely to the consideration of diseases and dystrophies of the nails. The book is profusely illustrated; most of these illustrations and enlargements are excellent. The author discusses the anatomy and histology of the nails, and takes up the dystrophies and diseases which are peculiar to the nails and those which affect the nails as part of a systemic dermatosis or other disturbance. The most common affections, which are the occupational paronychia, psoriasis, and fungus infections, are considered in detail. Inasmuch as the treatment of diseases of the nails represents one of the most difficult therapeutic problems that confronts the dermatologist, the author provides liberally from his experience, giving valuable hints. It is stated that one of the most useful agents available for the treatment of diseases of the nails is the roentgen ray and this phase of the subject is discussed in a separate chapter. The book is an excellent brief reference work for the general practitioner.

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ANEURYSM

Cure of a Traumatic Aneurysm by Radium Therapy. L. Valach. Strahlentherapie, 1937, **58,** 230.

A man 25 years of age developed an aneurysm of the left carotid following a stab wound. On admission, the circumference of the neck on the right was 17.5 and on the left 21.5 cm. The author treated him with radium in December, 1935, the technic being described in detail. Six months after the last treatment (September, 1936) the patient was free from symptoms, there was a smooth scar in the treated area, and the neck measurements were 17.5 cm. (right) and 18 cm. (left).

ERNST A. POHLE, M.D., Ph.D.

ANIMAL EXPERIMENTATION

Animal Experiments Dealing with the Epilating Effect of Roentgen Rays in its Relation to Roentgen Dermatitis: The Influence of the Treatment Technic on this Effect. B. Dahl. Strahlentherapie, 1937, **58,** 336.

The author exposed the hind legs of white rats to roentgen rays in order to study the relation between epilation and skin reaction. Technic: 180 kv., 20 cm. F.S.D., 3 mm. Al, H.V.L.$_{cu}$ 1.8 mm. (?), 85 r per minute. The doses varied from 160 to 3,500 r; the animals were observed up to 205 days. Permanent alopecia was obtained after the application of from 1,600 to 2,240 r, which also produced a very marked dermatitis. Fractionating and protraction of the dose did not influence the relation between epilation and dermatitis but only decreased the degree of change as compared with the single dose application. The comparison of three qualities of radiation (180 kv., filtered through 2 mm. Cu + 2 mm. Al, 180 kv., no filter, and 80 kv., 1 mm. Al, or no filter) did not reveal any influence of the wave length on the biologic effect provided that the radiation intensities were the same.

ERNST A. POHLE, M.D., Ph.D.

APPARATUS

The Panzer Dosimeter, an Instrument for the Measurement of All Therapeutic Radiations. H. Hase. Strahlentherapie, 1937, **58,** 161.

This instrument derives its name from the heavy lead protection which surrounds it like the armor (*panzer*) of a battleship. Its construction is described in detail, with a brief outline of its applicability in the dosage of roentgen rays, stray radiation, and radioactive material.

ERNST A. POHLE, M.D., Ph.D.

A Protective and Adjustment Device for Measuring Roentgen Rays in Absolute Units. E. Hasche. Strahlentherapie, 1937, **58,** 170

The author describes an attachment to a shock-proof therapy tube which facilitates the determination of the r unit, at the same time providing ample protection for the observer.

ERNST A. POHLE, M.D., Ph.D.

BONES, ANOMALOUS

Anomalous Bones of the Wrist and Foot in Relation to Injury. W. Warner Watkins. Jour. Am. Med. Assn., Jan. 23, 1937, **108,** 270–272.

Dwight lists 12 anomalies represented by distinct supernumerary bone formations in and about the wrist, any one of which can be mistaken for fracture.

(1) *Divided scaphoid (navicular) bone:* This bone usually ossifies from a single center but may develop from two centers, and these may fail to fuse. Closely akin to this, but less frequently seen, is the divided semilunar (lunate). The clinical importance of a divided scaphoid (or semilunar) is that the condition represents a mechanically faulty construction. These two bones in their articulation with the os magnum (capitate) form the keystone of the wrist joint. Dislocation forward on the os magnum occurs more readily, a situation hardly compensated for by the fact that reduction can be more easily accomplished than is otherwise the case. The line of division in a subdivided scaphoid or semilunar is not a true joint, and trauma is usually followed by bone reaction along this line of junction. Such a reaction is difficult to distinguish from that which occurs in traumatic fracture with an abortive attempt at union. When a person with such anomalous conditions in the wrist attains full growth and enters an occupation that subjects the joint to strenuous use and repeated trauma, the first x-ray examination thereafter is very likely to reveal a dense and devitalized bone—the typical Preiser or Kienböck lesion. It is quite obvious that the management of a case of congenitally divided scaphoid, or one that has been divided by some old injury, should be quite different from a case of recent fracture. Therefore the proper interpretation of the conditions shown by the x-ray becomes of paramount importance.

(2) *Os triangulare or ununited styloid process of the ulna:* The condition occurs often enough to be a matter of importance to industrial surgeons in determining whether the separate fragment found by x-ray examination following an injury to the wrist is a true anomalous bone, an old fracture with non-union, or a recent fracture.

(3) *A secondary pisiform bone may exist,* seen more distal in the carpus than the os triangulare.

(4) Still more rare is *the ulnare externum,* a separate fragment associated with the cuneiform (triquetral) bone.

(5) *The os centrale more often persists as cartilage,* even in the fully developed wrist. In such cases it is seen as an area of absent density in the radial side of the os magnum. When ossified, it may be joined to the scaphoid or, more rarely, may exist as a separate ossicle.

(6) *The radiale externum is a separate bone fragment* found just distal to the styloid process of the radius. It is not associated with the radius but is an unfused tubercle of the scaphoid (navicular) bone.

(7) *The epilunatum is the dorsal tip of the semilunar (lunate) bone,* which occasionally exists as a separate fragment.

(8) *The pretrapezium is the distal end of the ridge of the trapezium (multangular majus),* which may occasionally exist as a separate fragment.

(9) *The subcapitatum is the distal end of the os magnum (capitate)* on the palmar surface, which has been found as a separate fragment.

(10) *The secondary trapezoid is a free bone* found in almost the same position as the pretrapezium but arising from the base of the second metacarpal bone.

(11) *The styloid process of the second metacarpal bone* may develop independently and remain free or become fused with the trapezoid (multangular minus) or os magnum (capitate).

(12) *The os vesalianum manus is a free bone* situated at the base of the fifth metacarpal. The tubercle for the attachment of the extensor carpi ulnaris varies considerably in size, and a fragment of it may exist as a separate ossicle.

In the foot and ankle region there are 12 anomalous bones which need to be recognized.

(1) *The os trigonum:* The posterior projecting portion of the astragalus (talus) is grooved for the tendon of the flexor hallucis longus. External to this groove is a prominent tubercle, the posterior process, to which the talofibular ligament is attached. This process varies greatly in size and shape; it is often observed developing as a separate epiphysis in the growing individual, and various degrees of fusion are found in the adult. In about 10 per cent of cases this process or tubercle is found as a separate or incompletely fused bone.

(2) *The tibiale externum:* Two structures are called by this name. One is a sesamoid in the tendon of the tibialis posticus; the other is the unfused tuberosity of the scaphoid (navicular) bone. Both of these are seen frequently. The sesamoid bone is usually separated sufficiently from the scaphoid so that the question of fracture is not raised. However, the ununited epiphyseal tuberosity, or true tibiale externum, is often quite confusing. Since the tendon of the tibialis posticus muscle is inserted into this tuberosity and is one of the chief muscles of plantar flexion, a forcible dorsiflexion might, and no doubt often does, rupture this attachment and, along with the tendon injury, may detach a fragment of bone.

(3) *The os peroneum:* A sesamoid bone in the tendon of the peroneus longus where that muscle grooves the cuboid bone. Its position varies considerably, sometimes well forward under the cuboid, at other times more posterior beneath the head of the os calcis (calcaneum) or in an intermediate position under the calcaneocuboid articulation; it also varies much in size, shape, and density and may be subdivided.

(4) *The os vesalianum pedis:* The unfused tuberosity at the base of the fifth metatarsal bone.

(5) *The secondary os calcis:* The result of calcification in the interosseous cartilage between the anterior process of the os calcis (calcaneum) and the scaphoid and cuboid. This may fuse with the projecting angle of the os calcis proper or with the scaphoid, or it may remain as a distinct extra bone.

(6) *The intermetatarseum:* This is an extra bone located between the internal cuneiform and the first two metatarsal bones.

(7) *The secondary cuboid:* This may occur as a separate fragment but is usually fused with the scaphoid at the lower and outer edge of that bone.

(8) *The subdivided internal cuneiform:* Of rare occurrence.

(9) *The intercuneiform:* A wedge-shaped bone on the dorsum of the foot in front of the scaphoid.

(10) *A divided sesamoid of the great toe:* A fairly frequent anomaly and often misinterpreted as a fracture.

(11) *A separate styloid tip of the fibula.*

(12) *A separate styloid tip of the internal malleolus.*

CHARLES G. SUTHERLAND, M.B. (Tor).

CALCULI

Observations on the Formation and the Prevention of Calculi. I. Snapper, W. M. Bendien, and A. Polak. British Jour. Urol., December, 1936, **8,** 337–345.

The authors came to the following conclusion: urine is a supersaturated solution of many substances. Large quantities of different substances, practically insoluble, are present in solution in it. This may partly be explained by the simultaneous presence of other so-called hydrotropic substances which further the solubility of the insoluble salts. The hydrotropic action of urea, hippuric, salicylic, and mandelic acid is discussed. Besides this hydrotropic action of the substances just mentioned, the presence of different colloids may also collaborate to the solution of the insoluble salts. Chondroitic sulphuric acid and nucleic acid may help specially to keep the insoluble salts in solution.

However, for the calculogenesis the precipitation of colloids is more important than the precipitation of salts. In the formation and the growth of kidney stones flocculation of colloids is the primary process—which is followed only by secondary incrustation with salts. Therefore it must be possible to prevent calculogenesis by preventing precipitation of colloids. Different organic salts can be used for stabilizing solutions of colloids. Experiments show that the hippuric acid of the urine must belong to these colloid stabilizing substances.

Thus the hippuric acid of the urine might prevent formation of stone nuclei by stabilization of the colloids or secondary incrustation by its hydrotropic action. Administration of sodium benzoate by mouth did prevent stone formation in rats on $CaCO_3$ rich diet. It also stopped phosphaturia in men and diminished renal colic in patients. The authors also state that other more powerful stabilizers of the colloids of the

urine (salicylates, mandelates) might be used for this purpose.

DAVIS H. PARDOLL, M.D.

CANCER (DIAGNOSIS)

Investigations of Blood-serum Lipoids in Cancer and Other Cases; Mean Molecular Weight of Free and Combined Acids in Blood-serum Lipoids of Cancer and Other Subjects; Ultra-violet Absorption Measurements. H. H. Barber and L. A. Woodward. Biochem. Jour., August, 1936, **30,** 1463–1471. (Reprinted by permission from British Med. Jour., Dec. 19, 1936, p. 104 of Epitome of Current Medical Literature.)

Barber reports having investigated von Noël's method (*Strahlentherapie,* 1931, **42,** 616) of diagnosing cancer from the chemical analysis of blood-serum lipoid. L. A. Woodward in Part II of the same paper reports having tested the claim that cancer can be diagnosed from the shape of the ultra-violet absorption curve given by the blood-serum lipoids. The chemical analysis consists in the determination of the fatty acid and saponification values of the lipoid, from which values the "Krebzahl" is calculated. According to von Noël, Krebzahl values of over 130 are indicative of cancer. Barber found that the Krebzahl values of 19 specimens of blood from advanced cancer cases had a mean of 205 and a range of 107 to 300, while the values for 22 specimens from non-cancer cases had a mean of 199 and a range of 86 to 304. There is no indication from these figures that a high Krebzahl is characteristic of cancer, and Barber suggests that the detection and estimation of the acids of low molecular weight generally considered to be characteristic of the abnormal glycolysis of malignant tumors are not quantitative by the methods employed to determine the Krebzahl.

Woodward, using a double quartz monochromator and photo-electric spectrophotometer, measured at ten different wave lengths the extinction coefficients of the alcohol-ether solutions of the serum lipoids from nine of the cancer cases and 11 of the non-cancer cases investigated by Barber. As only the relative shapes of the absorption curves were to be compared, corrections for variations in the molecular concentrations of the lipoids were unnecessary. He was unable to find any characteristic differences in the curves such as might serve as a diagnostic test for cancer. Both methods of testing the serum lipoids seem, therefore, to be useless for the diagnosis of cancer.

CANCER (THERAPY)

Supplementary Treatment of Cancer Patients. H. Auler. Strahlentherapie, 1937, **58,** 204.

The author discusses in a very general way some of the measures which may be considered as adjuncts to irradiation in the treatment of cancer. He mentions medication, chemotherapy, vaccines, sera, hormones, catalyzers, and also diet. In regard to the latter, he does not advocate the so-called raw food diet but believes that a well varied and balanced diet is the best. Climatic conditions also may be of importance.

ERNST A. POHLE, M.D., Ph.D.

THE COLON

Diffuse Adenomatosis of the Colon. Fred W. Rankin and Allen E. Grimes. Jour. Am. Med. Assn., Feb. 27, 1937, **108,** 711–715.

Diffuse adenomatosis of the colon as a distinct clinical entity has been recognized for many years, but the histopathology revealing its malignant tendency has been a more recent contribution which has done much to alter modern views with regard to treatment.

The tumors are usually multiple and widely distributed, often extending from the anus to the cecum, but have a tendency to appear approximately eight times more frequently in the rectosigmoid and rectum than in any other section of the colon. This is particularly significant in the light of the similar occurrence and ratio of distribution of carcinoma of the colon. It suggests a relationship and studies of large segments or the complete colon exhibiting this form of pathologic involvement have supported this suspicion.

A familial tendency or hereditary factor has been repeatedly sustained by various investigators and conforms with their experience.

The terms "polyposis," "polypoidosis," and "diffuse adenomatosis" have been frequently used to designate the adenomatous hyperplasia. "Polyposis" may mean only one or several polyps, while "polypoidosis" indicates that the entire inner surface of the large bowel, from the anus to the cecum, contains polyp-like elevations.

The cause of true adenomatosis has not been determined. The origin of the acquired or post-inflammatory polyps is quite different and better understood. Although the etiology of post-inflammatory and true polyps is accepted as being different, one must not forget that the former as well as the true polyps may undergo malignant change.

A pathologic study of true polyps of the colon emphasized the potential malignancy of this condition and greatly influenced the method of treatment. On histologic examination, the tumors fell readily into three major divisions: (1) Roughly nodular and invariably pedunculated, with no features to indicate that they were any more liable to malignant development than the normal intestinal mucous membrane; (2) polyps showing structural changes in both the epithelial and the connective tissue elements—this group is often the source of malignancy; (3) polyps of this group ordinarily do not exceed the size of a split pea; the nodules approach cancerous changes before the tumor has become large enough to be played on by the forces of peristaltic action, which is thought to be influential in elongating the tumors.

There is usually little difficulty in establishing the diagnosis if the condition is kept in mind and the patient is subjected to a thorough gastro-intestinal

investigation, including roentgenologic examination of the barium-filled colon.

CHARLES G. SUTHERLAND, M.B. (Tor.).

CONTRAST MEDIA

Epidural Lipiodol in Sciatica. G. Carriere and A. Verhaeghe. Écho Méd. du Nord, July 26, 1936, **6,** 186–197. (Reprinted by permission from British Med. Jour., Oct., 10, 1936, p. 58 of Epitome of Current Medical Literature.)

According to the authors this treatment, introduced in 1924, has recently been reported to have induced speedy improvement in 70 per cent of a series of 1,500 cases of sciatica. The lipiodol is injected into the connective tissue below the dural sac, through the posterior inferior obturating membrane; this has the shape and position of a triangle of which the upper angle is formed by the last (that is, the fourth or third) sacral spinous process and the lower two angles by the two posterior internal sacral tubercles. Injected in sufficient amount (20 c.c. is stated to be essential), the lipiodol passes up extradurally as high as the second lumbar vertebra and sends prolongations along the nerve roots; these are bathed in lipiodol, in the case of the sacral plexus, for 10 cm. Injection, otherwise very painful, should be preceded by local anesthesia of the skin (2 c.c. of 2 per cent scurocaine) and injection of the track by 20 c.c. of 0.5 per cent solution. A wait of fifteen minutes now precedes the slow injection of lipiodol, which, like the anesthetic solution, is given through a screw syringe, such as that of Lafay, with a needle not longer than 5 cm. (Longer needles may cause an involuntary lumbar puncture.) To reach the epidural space the syringe, after being introduced perpendicularly to the obturating membrane, is tilted downward at 60 degrees at the butt, and now penetrates the canal upward and parallel with its long axis. Of the three bony points to be recognized, the lower two are usually easily felt, and a puncture 5 to 7 mm. above the line joining them will be successful: if the upper one only is palpable, the needle should be put in directly below it. The lumbar puncture needle is unsuitable, being too long, too frail, and too fine. The insertion may be assisted by radiographic control.

GYNECOLOGY AND OBSTETRICS

The Influence of Irradiation of the Thyroid on the Ovary. E. Momigliano. Strahlentherapie, 1937, **58,** 53.

In order to study the relation between thyroid and ovary the author exposed the thyroid gland of adult rabbits to roentgen rays. The anterior cervical area was irradiated with from 375 to 2,250 r; the average dose varied between 750 and 1,500 r (184 kv., 0.7 mm. Zn, 23 cm. F.S.D., 5 × 7 cm. sq. field). Four animals were exposed at intervals of one month, four untreated rabbits being kept as controls. The histologic changes seen in the thyroid are described in detail and illustrated by photomicrograms. They varied according to the dose and the time interval between exposure and histologic study. Following 375 r there was only slight hyperemia of the thyroid, while with higher doses cystic degeneration with destruction of the follicle epithelium and hyperplasia of the interstitial tissue occurred. The peak of the reaction was seen four months after the exposure. The ovaries in the same animals were also studied histologically, and the observed changes are described and illustrated by photomicrograms. It was interesting to note that rabbits showing marked changes in the thyroid showed also definite histologic changes in the ovaries. As a matter of fact, animals that received 2,250 r over the thyroid showed marked atrophy of the ovaries four months after the thyroid exposure. In other words, irradiation of the thyroid led to a true sterilization. The author emphasizes that in contrast to statements made in the literature as to the relatively high radioresistance of the thyroid, he found the gland definitely radiosensitive and refers to his histologic observations.

ERNST A. POHLE, M.D., Ph.D.

HEMORRHAGE

Classification and Treatment of the Hemorrhagic States. Stacy R. Mettier and Katherine Purviance. Jour. Am. Med. Assn., Jan. 9, 1937, **108,** 83–86.

The difficulties inherent in the problem of bleeding and blood clotting offer limitations in constructing an entirely satisfactory classification of the hemorrhagic states. A classification from a clinical point of view may be made, depending on the defect in the clotting mechanism or the vascular tree.

In addition to a carefully taken history of the course of the illness and a thorough physical examination, laboratory aid is necessary for the diagnosis of hemorrhagic diseases. Since specific nutritional elements are needed to maintain the integrity of capillaries and to form liver and blood proteins, a detailed history of the dietary habits of the patient should be recorded.

On the basis of the information gained with regard to a familial hemorrhagic tendency, the physical signs and the abnormalities of the blood, the hemorrhagic diseases may be classified, within limitations.

In a survey of the therapeutic measures repeated roentgen irradiation over the spleen in suitable dosage is given as an excellent means of increasing the number of circulating blood platelets in patients with idiopathic thrombocytopenic purpura hemorrhagica.

CHARLES G. SUTHERLAND, M.B. (Tor.).

THE PROSTATE

Early Diagnosis and Radical Treatment of Carcinoma of the Prostate. Edward L. Keyes and Russell S. Ferguson. British Jour. Urol., December, 1936, **8,** 346–352.

The authors are of the opinion that carcinoma of the prostate should be attacked as a curable disease. No

large proportion of cases will be controlled unless diagnosed by (aspiration) biopsy before diagnosis is possible by rectal touch, even with a sound in the urethra.

They propose an operation which, with low operative mortality, promises to compare favorably with the total prostatectomy of Young. Grave post-operative radium burns are preventable by proper technic, and such prevention is especially easy to assure in the early curable cases.

DAVIS H. PARDOLL, M.D.

The Conservative Treatment of Carcinoma of the Prostate. Cyril A. R. Nitch. British Jour. Urol., December, 1936, **8,** 329–336.

The conservative treatment given by the author comprises radiotherapy, surgery, and surgery with radiotherapy.

The immediate results of x-ray treatment are often excellent, but the ultimate results are disappointing. In some cases x-rays cause rapid increase of the growth and dissemination. The best results are obtained by the five-field maximum method (Holfelder-Reisner), giving a total depth dose of from 150 to 200 per cent on the prostate. The intensive split-dose method of Levitt, now under trial, seems productive of better results. At present only 6 per cent of the cures can be claimed for modern methods of x-ray therapy.

The effects of radium are better, especially when applied in large doses to the rectal, vesical, and urethral surfaces of the prostate. Before treatment is commenced, a thorough clinical, biochemical, and radiological examination must be made, and a portion of the prostate should be removed by electro-resection for microscopical examination. When renal function tests are below normal, preliminary drainage of the bladder is necessary. About 70 mg. of radium are used thus: 14 mg. to the postero-lateral surfaces, 50 mg. to the vesical surface, and 5 mg. to the urethral surface. Though only a few cases have been treated in this way the cure rate up to the present has been 28 per cent. The method is, therefore, worth an extended trial.

Conservative surgery consists of suprapubic drainage, transplantation of the ureters, and electro-resection. Transplantation of the ureters into the large intestine is preferable to suprapubic drainage but can be performed only in carefully selected cases. Electro-resection is the best palliative measure for the relief of obstruction by growth at the neck of the bladder; it is of no value when the obstruction is due to invasion of the prostatic urethra. It is probable that in the future electro-resection, followed by some form of radiotherapy, will be the method of choice.

DAVIS H. PARDOLL, M.D.

THE SKIN

Arthropathica Psoriatica. Harold Jeghers and Leon J. Robinson. Jour. Am. Med. Assn., March 20, 1937, **108,** 949–952.

Arthropathica psoriatica (psoriasis arthropathica) as a distinct clinical entity has been of particular interest since Alibert, in 1822, recognized the occurrence of joint pains in psoriasis. Bazin, in 1860, distinguished between psoriasis with arthritis and without arthritis and applied the term "psoriasis arthritica" to the former variety. Adrian reviewed the subject in 1903 and did much to establish this syndrome as a clinical entity.

Since cases are so rarely reported, the syndrome is probably an unfamiliar one. O'Leary saw eight instances of this syndrome among 1,400 cases of psoriasis.

In reported cases the dermatologists tend to ignore the arthritis, while the internists pay little attention to the skin lesions.

The diagnosis of true arthropathica psoriatica depends mainly on the close relationship which the exacerbation and subsidence of the skin and joint manifestations bear to each other.

Joint manifestations commonly appear a short interval (from days to weeks) following a change in the form of the psoriasis. The skin lesions become erythematous, atypically distributed, increased in extent and/or pustular. The arthritis is usually polyarticular and involves both small and large joints. Severe symmetrical involvement of the terminal joints of the fingers and toes has been commented on as common and characteristic. This may occur whether or not the other joints of the fingers and toes are involved. There is also a striking parallelism between the severity of the skin and joint manifestations.

Psoriatic arthritis lasts from weeks to months but may in rare cases persist permanently. The skin lesions usually subside either spontaneously or after appropriate therapy, followed in a few weeks by recession of the arthritic symptoms.

The syndrome may be repeated several times, at yearly or longer intervals. A characteristic feature in most cases is the marked return of joint function after the first or first few attacks. However, permanent joint damage may follow repeated or long-standing attacks of this syndrome.

The joint lesions are not characteristic and may resemble either rheumatoid arthritis or osteo-arthritis. The changes vary from slight peri-articular swelling to actual destructive lesions. Intermittent hydroarthrosis may occur. A typical joint is swollen, tender, and warm to touch and with painful and limited mobility. Ankylosis is rare at the start but may occur later.

The roentgen picture varies and is not characteristic. Narrowing of the joint space, peri-articular swelling and slight bone atrophy are common in the early phase. After repeated or long-standing attacks, hazy outline of the bone, roughening of the articular surface, destructive changes and occasionally hypertrophic reactions which cause ankylosis may appear.

The parallelism between the severity of the skin and joint lesions seems to support the theory that the arthritis is due to toxic products absorbed from the skin lesions.

CHARLES G. SUTHERLAND, M.B. (Tor.).

THE SKULL

The Roentgenologic Appearance of the Skull in Cases of So-called Genuine Epilepsy. E. Fischel. Archivio di Radiologia, March–April, 1936, 114–120.

This is a preliminary report of a study Fischel made of the skulls of 21 cases of so-called genuine epilepsy. Many of the skulls showed some, though perhaps slight, abnormality. He feels that the term "genuine epilepsy" should be limited to those rare instances in which there is no roentgenologic, developmental, or circulatory lesion which might cause the disease.

E. T. Leddy, M.D.

THE SPINE

Osteomalacia of the Spinal Column. E. Meulengracht and A. Rothe Meyer. Ugeskrift for Laeger, Oct. 8, 1936, **98,** 961–986. (Reprinted by permission from British Med. Jour., Dec. 19, 1936, p. 101 of Epitome of Current Medical Literature.)

The authors trace the changes in the conceptions of the pathology of osteomalacia since Trousseau, in 1868, maintained that it was identical with rickets and curable with cod-liver oil. At the beginning of this century osteomalacia was regarded as a disease of the endocrine glands. Now the swing of the pendulum has taken osteomalacia out of the sphere of the endocrine glands and identified it as a deficiency disease closely related to rickets and traceable to disturbances of calcium and phosphorus metabolism due to lack of vitamin D.

The authors give an account of four cases of osteomalacia of the spine observed in the course of the past three years, the ages of the patients being, respectively, 58, 42, 64, and 77. The disease developed in the first case in the course of from four to six years, during which the patient was subject to constant pain in the shoulders, back, and loins. Rapid and striking improvement, which has now been maintained for over two years, was effected under treatment with vitamin D and calcium. In the second case, a man had for five years systematically lived on an inadequate diet on account of his dyspepsia. He developed pain in the back, and the x-rays showed extensive destruction and collapse of the dorsal and lumbar vertebræ. On a liberal mixed dietary, including vitamin D and calcium, the pain ceased, the progress of the bony disease was arrested, and the improvement thus achieved was maintained. After giving details of the other two cases, the authors point out that common to all was a defective dietary over a long period, and hour-glass deformity and collapse of certain vertebræ, and a remarkably rapid and durable recovery in response to the exhibition of vitamin D and calcium. The authors also give an account of a fifth patient, a man of 69, who lived by himself and who developed not only scurvy due to his defective diet but also radiologically demonstrable deformity of the lumbar vertebræ.

TUMORS (DIAGNOSIS)

Tumors of the Mediastinum Arising from the Reticulo-endothelial System Roentgenologically Considered. W. G. Herrman. Jour. Med. Soc. New Jersey, December, 1936, **33,** 693–695.

Because of the inaccessibility of mediastinal tumors and the rarity of mediastinal biopsies, the roentgenologist carries a great responsibility in such conditions. Careful fluoroscopy is the first procedure, with an intensive study in various positions. Radiographs should then be taken in positions determined by fluoroscopy as being most helpful, including postero-anterior, lateral, and oblique views. The use of iodized oil, artificial pneumothorax, and barium may help in localization as well. Substernal thyroid, enlarged thymus, benign tumors, such as dermoids and neuromas must be differentiated. Aneurysms often prove very difficult to differentiate. Metastatic malignant tumors, lymphosarcomas, and Hodgkin's disease are other considerations. Sensitiveness of tumors to radiation therapy may help in diagnosis.

W. A. Sodeman, M.D.